AD 267 628

04625-1-F

THE UNIVERSITY OF MICHIGAN

COLLEGE OF ENGINEERING
DEPARTMENT OF NAVAL ARCHITECTURE AND MARINE ENGINEERING

Final Report

Bibliography of Selected Literature of Low Maintenance Ship Propulsion Plants

GEORGE L. WEST, JR.
I. YILMAZ EGRIKAVUK

62-1-4

Under Contract With:

Department of the Navy
Office of Naval Research
Contract No. Nonr 1224(43)
Washington, D. C.

Administered Through:

October 1961

OFFICE OF RESEARCH ADMINISTRATION · ANN ARBOR

THE UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING
Department of Naval Architecture and Marine Engineering

Final Report

BIBLIOGRAPHY OF
SELECTED LITERATURE OF LOW MAINTENANCE SHIP PROPULSION PLANTS

George L. West, Jr.
I. Yilmaz Egrikavuk

ORA Project 04625

under contract with:

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
CONTRACT NO. Nonr-1224(43)
WASHINGTON, D.C.

administered through:

OFFICE OF RESEARCH ADMINISTRATION ANN ARBOR

October 1961

CONTENTS

ABBREVIATIONS, Cont.

Technical

bhn---brinnel hardness number
bhp---brake horsepower
bmep---brake mean effective pressure
cc---cubic centimeter
fps---feet per second
gpm---gallons per minute
HP---high pressure
hp---horsepower
kg---kilogram
lb---pound
lb in---pound inch
LP---low pressure
mg---milligram
mm---millimeter
ppm---part per million
psi---pounds per square inch
psia---pounds per square inch absolute
psig---pounds per square inch gauge

Reference

J---journal
n---number
p---page
pp---pages
PROC---proceedings
Pt---part
Rev---revision
Suppl---supplement
TRANS---transactions
v---volume

INTRODUCTION

The work of compiling this bibliography was sponsored by the Office of Naval Research. At the outset, it was realized that the topic, Low Maintenance Ship Propulsion Plants, could cover a broad range of material. In fact, it can be argued that almost any development aimed at producing an improvement in ship's machinery can be construed as tending to reduce maintenance. The subject could be interpreted to include such items as refinements in the theory of lubrication or even a discussion of quantum mechanics. The authors believed, however, that the subject would have to be limited to the more direct aspects of the problem.

Any paper which discussed maintenance of ship's propulsion plants was automatically considered. The second criteria which was used was to consider those publications which discussed a problem and also proposed a solution. In both cases, the proposal had to lead to an improved plant or reduced maintenance. A few papers have been included which were considered to be idea stimulators and did not fit in either of the above categories.

The bibliography which follows was thus strongly influenced by the authors' judgment of the various publications. The most difficult problem was deciding on those papers to include since there were many more papers than could be read in the time alloted. Different authors would undoubtedly have included some papers which were rejected and rejected others that are included.

In the beginning, this was to be a "complete" bibliography. After one day, it was obvious that it would be a highly selected bibliography. A survey of the Library of Congress and the Technical Societies Library in New York had been intended. As the investigation progressed, it was found that there was more material in The University of Michigan libraries than could be read in the time available. Therefore, no attempt was made to survey libraries outside Ann Arbor.

After surveying the literature for three months, one fact is obvious. The over-all problem of reducing ship propulsion plant maintenance has received little consideration. Most of the papers included in the present bibliography are concerned with specific problems and equipment. Few of them consider the over-all problem of reducing maintenance.

Indexes, such as The Engineering Index, were surveyed back through 1955. Selected publications, such as The Society of Naval Architects and Marine Engineers Transactions, were surveyed through 1945. Occasional papers older than 1945 are listed. Most of these are from The Institution of Naval Architects Transactions. In general, it was not productive to consider material prior to 1945.

The bibliography is arranged in three parts. The first part contains the abstracts of the articles which the authors read and considered to be germain to the subject. The second part contains a list of the articles which were read and considered to have little value relative to low maintenance ship's machinery. The final part contains a list of titles which may have value but were not read because of lack of time.

The annotated bibliography is arranged by subject. Under each subject, the papers are arranged by date---the latest paper first. All the undated papers in any one year or category come at the end of that year or category. The subject classification, in many cases, is arbitrary since some papers could fit equally well under two headings. The rejected and unread papers have been listed chronologically without regard for subject.

The authors wish to acknowledge the assistance of John Couch, Kemal Uygan, Elizabeth Benford, and Helen Walker.

ABSTRACTS OF PERTINENT ARTICLES

BOILERS

1. "Corrosion of Welded or Coated Steel and of Wrought Iron Boiler Tubes in Highly Saline Water," G. Butler and H. C. K. Ison; INTERNATL SHIPBLDG PROGRESS, v 8, n 78, February, 1961, pp 81-101.

   Welded tubes are susceptible to deep pitting and perforation, particularly in the weld region. The corrosion of mild-steel tubes is reduced by chromizing or phosphating. Possible reasons for extended life are discussed.

2. "Acid Deposition in Oil Fired Boilers---Trials of Additives," P. A. Alexander, R. S. Fielder, P. F. Jackson, E. Raask, T. B. Williams; I FUEL J, v 34, February, 1961, pp 53-72.

   Basic additives used: magnesium carbonate, proprietary additive, and zinc. All three additives reduced the concentration of sulphur trioxide in the flue gas at the inlet and outlet of the air heater compared with the no-additive test. Magnesium carbonate was slightly more effective despite the considerably higher sulphur content of the fuel. All oil-fired boilers should be operated with the minimum practicable amount of excess air, to suppress the formation of sulphur trioxide.

3. "Combustion Equipment for the CANBERRA," THE SHIPPING WORLD, v 142, February 17, 1960, pp 209-210.

   The article describes A.B.C. oil burners on the CANBERRA, which are arranged for either straight pressure jet or steam-assisted atomization. It is claimed that this new design, especially using steam-assisted atomization, minimizes boiler maintenance.

4. "Boiler Tube Failures," R. C. Ulmer, E. P. Partridge, I. B. Dick; COMBUSTION, v 31, n 6, December, 1959, pp 43-52.

   This is a further discussion of the topic "Water Side Boiler Tube Failures" by R. C. Ulmer, COMBUSTION, August, 1959. Additional and divergent views are included. This is only broadly applicable to ships since it is directed at utility problems.

5. "Care and Maintenance of Water Tube Boilers," W. R. Harvey; I MAR E TRANS, v 71, n 11, November, 1959, pp 333-353.

   Suggestions and precautions applicable to boiler units in modern steamships are given. Reference is made to design

only where it has definite bearing on maintenance. Endeavor has been made to give basic reasons for given troubles, the means to cure them and, if possible, to avoid repetition. The paper discusses nearly all phases of boiler problems.

6. "Water Side Boiler Tube Failures---Their Origin and Treatment," R. C. Ulmer and V. C. McCabe; COMBUSTION, v 31, n 2, August, 1959, pp 47-51.

   A discussion covers factors of water treatment and boiler operation which influence tube failures. This is a general discussion which offers little in terms of quantitative data.

7. "Supercharger for Pressure Fired Boiler," R. C. Reisweber, J. W. Glesner, J. R. Shields; GAS AND OIL POWER, v 54, January, 1959, pp 16-18.

   In contrast with aircraft gas turbine practice, a boiler supercharger is designed with the emphasis on long life and accessibility for maintenance in line with usual marine requirements. Avoidance of serious blade vibration due to rotating stall was an important consideration, so a bleed off after the fourth stage was provided to increase flow through the inlet stages at low speeds. The first four stationary blade rows were made adjustable so that stall patterns could be altered by changing angles.

8. "The Controlled-Circulation Boiler," W. H. Armacost; ASME TRANS, v 76, 1959, pp 715-725.

   From the standpoint of circulation, there are two general types of boilers in operation: 1) natural circulation, 2) controlled circulation based on the use of a pump to distribute and circulate the water through the heat-absorption areas. This paper deals with the development, preferred designs, operating features, and low maintenance of controlled-circulation boilers.

9. "Noninteracting Controller for Steam-Generating Systems," K. L. Chien, E. I. Ergin, C. Ling, A. Lee; CONTROL ENGINEER, v 5, October, 1958, pp 95-101.

   This article reviews the boiler analysis and then goes beyond it, revealing the design of a noninteracting controller to improve boiler performance by limiting unwanted excursions of variables.

10. "Sulphuric Acid Corrosion in Oil Fired Boilers," D. R. Anderson

and F. P. Manlik; ASME TRANS, v 80, August, 1958, pp 1231-1238.

Experimental studies on economizer and air heater corrosion resulting from formation of sulphuric acid in residual oil fired boilers are described. Nickel, iron, sodium, and vanadium in the fuel each decreased the corrosion normally experienced by the test specimen.

11. "Stress, Crevice, Galvanic, and Uniform Corrosion of Austenitic Stainless Steels and Carbon Steel in High Temperature Boiler Feed Water: A Literature Review," R. B. Richman; HW-54879 (General Electric Co., Hanford Atomic Products Operation), February 6, 1958, 12 pp. Available from OTS and Depository libraries.

A bibliography is presented of 89 references to report literature on stress, crevice, galvanic, and uniform corrosion of stainless and carbon steel in high temperature boiler water.

12. "Sulphuric-Acid Corrosion in Oil-Fired Boilers---Studies on Sulphur-Trioxide Formation," D. R. Anderson and F. P. Manlik; ASME, paper n 57-A-199, December 1-6, 1957, 12 pp.

The small amount of sulphuric acid (20-50ppm) condenses on surfaces at temperatures up to 350° F and causes severe corrosion of the boiler construction material, especially on economizer and air heater surfaces. Sulphur-trioxide formation and the effect of fuel ash on low-temperature corrosion are discussed. Nickel, iron, sodium, or vanadium present in the oil tend to decrease corrosion by the reductive effect. Iron tends to increase corrosion due to formation of catalytically active surfaces. Mixtures of sodium oxide and vanadium pentoxide decrease corrosion.

13. "Effect of Mechanical Factors on Condensate-System Corrosion," R. G. Dalbke and J. F. Wilkes; ASME, paper n 57-A-183, December 1-6, 1957, 8 pp.

When deaerating heaters are operated properly, they eliminate oxygen and uncombined CO_2 from boiler feedwater. Potential CO_2 in steam condensate can be minimized by lime softening, lime-soda ash treatment, and zeolite softening. Morpholine is the best neutralizer for closed systems. Film-forming inhibitors and filming amines prevent attack by both CO_2 and dissolved oxygen. As a corrosion preventive measure for the air-leakage problem, the use of packless control valves for steam-heated process equipment is desirable. The use of welded or brazed joints is recommended as a corrosion-control measure. Proper design can correct impingement effect.

14. "Operating Experience and Results of Testing the First APDA Prototype Liquid Metal Once-Through Steam Generator," R. H. Jones, T. E. Lempges, H. J. Williams, J. Wooton; AECU-3700 (Atomic Power Development Associates, Inc.), December, 1957, 67 pp. Available from OTS.

The test of a model once-through liquid metal steam generator using seven full-length ½ inch OD tubes is described. None of the 25 unscheduled shutdowns was caused by failure of liquid metal components. One year of operation of the unit indicates the once-through steam generator to be entirely satisfactory.

15. "Prevention of Acid Condensation in Oil-Fired Boilers," L. K. Rendle and R. D. Wilson; COMBUSTION, v 29, n 1, July, 1957, pp 29-46.

Prevention of acid condensation on boiler tubes is studied with the following additives:
- ammonia (seems to be the best)
- zinc dust
- dolomite
- magnesium oxide
- magnesium soap
- zinc naphthenate
- magnesium naphthenate

16. "Keys to Superheater Protection," R. C. Bellas; POWER, v 101, n 6, June, 1957, pp 112-113, 232, 234.

Firing speeds, good start-up procedure effects on superheater design, superheater drains, and nondrainable superheaters are discussed.

17. "Keep Boiler Feedwater Silica Under Control," P. Brindisi; POWER, v 101, n 5, May, 1957, p 102.

Carbonate-sulfate scale yields to either mechanical or acid cleaning. Where silicates dominate scale composition, usual acid cleaning is virtually useless. Repeated chipping or turbining is the only recourse. For internal conditioning, alkaline phosphate-organic type treatment may be used. Magnesium hydroxide is an excellent silica absorbant. Hot lime-soda, filtering mediums, and demineralization are also discussed.

18. "Diet for Boiler Allergies," S. F. Whirl; ASME, paper n 57-A-257.

The paper considers chemical conditioning in this light, stressing advantages and limitations of the co-ordinated phosphate-pH control method of boiler water conditioning.

Considered also is the use of auxiliary chemicals such as sulfite, hydrazine, alkalizing amines and ammonia, and the numerous design and operation factors involved in evaluation of any boiler-water treatment method.

19. "Hydrazine---for Boiler---Feedwater Treatment," E. R. Woodward; POWER, v 100, n 11, November, 1956, p 80.

    Hydrazine-treated boiler feedwater appears to be a big step forward in the search for the ideal treatment which would produce feedwater of slight alkalinity, zero-dissolved solids, and complete absence of free oxygen. Hydrazine should play an important part in further reducing scale deposit and corrosion, thereby cutting downtime.

20. "Investigation into Air-Heater Corrosion of Oil-Fired Boilers," B. Lees; I FUEL J, v 29, n 183, April, 1956, pp 171-175; v 29, n 189, October, 1956, pp 441-447.

    To prevent air-heater tube corrosion and fouling outside the tubes, CO_2 percentage in the flue gases is increased as much as possible (13%) either by injection of oil into the base of the flame from the rear of the boiler, or by introduction of flue gases instead of air. CO_2 in the flue gas, if increased, decreases the dew-point temperature, which in turn reduces fouling.

21. "Boiler Cleaning Methods and Controls," L. B. Schueler; ASME, paper n 56-F-13, September 10-12, 1956, 10 pp.

    A new nozzle design for boiler cleaning is described. For steam blowing, stellited seating surfaces for integral blower valves give greater assurance of tight valves and lower maintenance cost. To prevent ramming of the condensed steam against the blower steam packing, steam supply piping is sectionalized. Electric soot-blower and control system is better than air system on the basis of low maintenance.

22. "Ideal Water Treatment and Blowdown Keep Your Boiler Clean," D. C. Swift; POWER, v 100, n 7, July, 1956, p 84.

    Complementing external water conditioning, the internal treatment by sodium-base salts and blowdown keeps scale and mud off internal surfaces and protects boiler metal against corrosion and embrittlement.

23. "Field Studies of Pre-Boiler Corrosion in Higher Pressure Steam Plants," H. A. Grabowski, H. D. Ongman, W. B. Willsey; COMBUSTION,

v 27, n 11, May, 1956, pp 46-51.

Systems of 1800 psig, 1300 psig, 1500 psig, 1000 psig, 1550 psig, 1250 psig, 2000 psig are investigated for pH control and additives as ammonia, sulfite, amines, hydrazine in the feedwater, and results are obtained which indicate corrosion can be reduced in pre-boiler circuit. Low-pressure heater drips should not be added directly to the condensate system.

24. "Four Water-Treatment Methods to Remove Algae, Hardness, and Dissolved Solids," D. C. Swift; POWER, v 100, n 5, May, 1956, p 88.

Chlorination, softening, distillation, and cation-anion exchange complete the external treatment for boiler water. Details on when these processes are used and how they operate are given.

25. "Vibration in Boilers," T. J. Lund; BUREAU OF SHIPS J, v 4, March, 1956, p 23.

This article covers the means to prevent panting and vibration in boilers, which causes damage to boiler brickwork.

26. "New Way to Remove Feedwater Silica," S. B. Applebaum and B. W. Dickerson; POWER, v 99, n 4, April, 1955, p 83.

Studies for a 650 psig boiler plant covered silica removal by demineralization, by hot-lime zeolite, and by salt splitting.

27. "Stop Scale Formation in Your Boiler with Proper Treatment," L. W. Fitzpatrick; POWER, v 99, n 2, February, 1955, p 106.

Solubility is the key to scale sludge problems. Protection comes from changing scale-forming salts into sludges that are easily blown down before these salts saturate the water.

28. "Experimental Boiler Studies of the Breakdown of Amines," C. Jackson; ASME TRANS, v 77, 1955, pp 449-453.

Morpholine is relatively stable at boiler pressures up to 2500 psi and steam temperatures up to 1200° F. The amount of breakdown of morpholine to ammonia increases quite slowly and uniformly up to 1200° F, the highest temperature tested. Of all the materials tested, morpholine most nearly fulfills the requirements for an ideal, volatile, alkaline material

for pH control in steam-generating systems.

29. "Hydrazine for Boiler-Feedwater Treatment," R. C. Harshman and E. R. Woodward; ASME TRANS, v 77, 1955, pp 869-873.

The physical and chemical properties of hydrazine are discussed, particularly as they relate to its use for scavenging dissolved oxygen in boiler feedwater. The amount of hydrazine to use, the methods of application, and the methods of control of dosage are described. The results of use of hydrazine for boiler-feedwater treatment in several central power stations are summarized.

30. "Action of Boiler Water on Steel-Attack by Bonded Oxygen," C. E. Kaufman, W. H. Trautman, W. R. Schnarrenberger; ASME TRANS, v 77, 1955, pp 423-432.

The paper includes information relating to attack by boiler water on steel of boilers and superheaters. Examples of aggressive action drawn from field experience are explored by metallographic study of damaged specimens. It is concluded that the power of bonded oxygen of water to react with steel can be curbed by making both chemical and physical changes in boiler systems.

31. "The Use of Additives for the Prevention of Low-Temperature Corrosion in Oil-Fired Steam-Generating Units," E. C. Huge and E. C. Potter; ASME TRANS, v 77, 1955, pp 267-278.

The use of dolomite will reduce the amount of sulphur trioxide present in the flue gases and will inhibit sulphuric acid corrosion. Furthermore, dolomite will reduce the quantity of ash depositing in the air heater and the amount of work necessary to keep these surfaces clean.

32. "Inspection, Explosion, and Breakdown of Boilers and Pressure Vessels," J Eyers; I MECH E PROC, v 169, 1955, pp 181-202.

Boiler failures are divided into two groups, careless operation and service defects due to mechanical and chemical attack, or overheating. Different causes are studied and cures given for boiler failures such as boiler explosion and collapse due to low water conditions, boiler failure by corrosion fatigue, explosion of boiler tubes, breakdown and explosion of economizers, explosion from steam and feed piping, and boiler-flue-gas explosion.

33. "Thermco Boiler Feed System," MAR ENGR AND NAV ARCH, v 77, n 937,

December, 1954.

The Thermco system aims to remove the dissolved oxygen and CO_2 from the feedwater inside the boiler but not in the water space. Among the advantages claimed are reduction of hard scale due to removal of the dissolved gases, relief of thermal stresses in the boiler due to delivering the feed on the surface of the water, and less likelihood of damage due to any oil carried by the feed being deposited on the heating surface.

34. "Reduction of Condensate-Line Corrosion," S. Jensen and E. R. Lang; ASME TRANS, v 76, 1954, pp 245-249.

Feed of cylohexylamine once a day provided better protection to both iron and copper alloys than was afforded by the ammonia naturally present in the system. Continuous feed of cylohexylamine along with sodium sulphite at the condensate pump discharge still further reduced the iron and copper content of the condensate and of the boiler feedwater. A low level of 0.02 ppm of Fe and 0.01 of Cu in the condensate have been attained in two plants.

35. "The Synthesis of Two Marine Water-Tube Boilers," L. Baker; I MECH E PROC, v 168, 1954, pp 135-157.

The paper gives the important lessons learned from the operation of oil-fired water-tube boilers at sea since 1925. A statement is given of certain of the basic requirements necessary to ensure prolonged and reliable service. Two fundamentally different designs of boilers for application in the same ship are presented.

36. "Tubular Air Heater Problems," E. F. Rothemich and G. Parmakian; ASME, paper n 52-A-125.

The paper discusses the occurrence of air heater deposits and their effect on performance, maintenance, and design. Suggestions are offered for minimizing the difficulties with new methods of design and operation.

37. "Phosphoric-Acid-Cleaning of Boilers," T. E. Purcell and S. F. Whirl; ASME TRANS, v 73, 1951, pp 135-139.

Phosphoric acid is a good solvent for acid-cleaning of boilers. This solution can be boiled at atmospheric pressure with negligible attack on the boiler metal, thus permitting the solution to be heated and circulated by normal low-level firing of the boiler. These solutions are stable

at atmospheric pressure and yield no corrosive vapors above the solution or noxious fumes in the plant. Boiler surfaces cleaned with phosphoric acid are resistant to rusting.

38. "Expanded Tube Joints in Boiler Drums with Reference to the BATTERSEA High-Pressure Boilers," W. B. Shannon, C. W. Pratt, T. B. Webb, W. B. Carlson; I MECH E PROC, v 154, 1946, pp 52-93.

It was realized that the leakage was due to the elastic strain which occurs in the tube holes of highly stressed drums. The elastic deflections, or total "spring" of the joint resulting from expanding operation, must be correspondingly increased to accomodate the increased drum strain. Various suggested methods of achieving this are reviewed. Insertion ferrules were selected as the most promising.

39. "Boiler Embrittlement," C. A. Zapffe; ASME TRANS, v 66, 1944, pp 81-126.

Boiler embrittlement is nothing but an intermediate stage in a naturally occurring hydrogen purification treatment. On pages 110-117, there are 427 references on boiler maintenance and corrosion.

40. "The Circulation of Water and Steam in Water-Tube Boilers, and the Rational Simplification of Boiler Design," W. Y. Lewis and S. A. Robertson; I MECH E PROC, v 143, 1940, pp 147-181.

An improved type of tube, approaching very nearly to the standard U-tube, is evolved to allow simplification of boiler design and the advantages of excellent circulation, high gas speeds, and higher heat transmission rates. Other simplifications and improvements are also rendered possible which enable substantial reductions in installing and maintaining boilers of any pressure and capacity.

41. "Water-Tube Boilers in Some Recent Merchant Ships with Service Results," H. E. Yarrow; INA, 1931.

Particulars of several marine boiler installations are given. A table of boiler repair and maintenance costs for four ships for a seven-year period is included. There is also a table of service results for six boiler installations.

42. "Boiler Deposits," V. B. Lewes; INA, 1891.

Fire tube failures caused by deposition of engine lubricant on the surfaces is discussed.

43. "On the Formation of Marine Boiler Incrustations," V. B. Lewes; INA, 1889.

    Scale formation and composition from sea, fresh (river), and distilled water are discussed along with water treatment.

44. "On Water-Tube Boilers," J. Fortescue Flannery; INA, 1876.

    This paper gives the history of recent water-tube boiler failures and some design details.

45. "On the Construction of Marine Steam Boilers," C. W. Williams; INA, 1862.

    This is an interesting paper, although it is of little use today.

46. "On Various Means and Appliances for Economizing Fuel in Steam-Ships," R. Murray, Esq.; INA, 1860.

    The problems of jet condensers, cylinder condensations, and of using sea water for boiler feed are discussed.

CORROSION

1. "Mercury-Inhibited Brass Tubes May Help," T. W. Edwards; POWER, v 104, n 6, June, 1960, p 245.

    Mercury-inhibited brass condenser tubes retard the buildup of deposits. Even after deposits have started to build up they are much more easily removed, usually by simple mechanical methods. Uniform corrosion in place of pitting corrosion lengthens tube life by retarding spot failure of the condenser tube wall.

2. "Corrosion Tests on Materials Exposed in Flue Gases from Oil Firing," M. Haneef; I FUEL J, v 33, June, 1960, pp 285-294.

    Corrosion rates of different materials have been determined in flue gases from an oil-fired, water-cooled furnace.

3. "Corrosion Curbed," MAR ENGR AND NAV ARCH, v 83, n 1007, May, 1960, pp 216-217.

Aqua-Clear has shown that it can reliably protect water circulation systems and water tanks, regardless of the quality and temperature of the water. It is used in liquid form as an additive for closed water circulation systems or storage tanks, including ballast tanks. For continuous flow systems, Aqua-Clear feeder is used in its hard crystal form. Results of the test indicate that corrosion weight loss with Aqua-Clear is in the same order as with potassium bichromate, but the loss is more evenly spread and local heavy pitting is less evident.

4. "Heterocyclic Amines for Flue Gas Corrosion Control," I FUEL J, v 33, April, 1960, pp 163-173.

Economizers, air heaters, and the ancillary ferrous equipment of boiler installations burning fuels of high sulphur content may be protected by the injection into the flue gases of 0.03 percent of heterocyclic tertiary amines by weight of the rated fuel capacity of the installation. When using amines as inhibitors, an advantage is the ease with which air heaters may be washed with water. Carbon deposits which accumulate are readily wetted and their removal presents no problem compared with that of bonded ferrous incrustations.

5. "Oxygen Removal with Hydrazine," T. F. Demmitt; HW-63534 (General Electric Co., Hanford Atomic Products Operation), January 25, 1960. Available from OTS and Depository libraries.

This study was initiated to determine the feasibility of using aqueous hydrazine to remove dissolved oxygen from water in low-temperature systems. Hydrazine is being investigated to determine its potential as an oxygen scavenger or corrosion inhibitor. The amount of oxygen removed by hydrazine increased as the reaction time, solution temperature, and initial hydrazine-to-oxygen ratio increased.

6. "Corrosion of Welded or Coated Mild Steel and of Wrought-Iron Boiler Tubes in Highly Saline Water," G. Butler and H. C. K. Ison; read at a meeting of NECIES, v 76, December 11, 1959, p 95.

Tests were set up to examine the influence of copper in the steel from which the tubes are manufactured and the effect of surface coating on the life of the tube examined (mild steel tubes chromized, coated with aluminum, phosphated). A comparison was made of the resistance to corrosion of mild steel and of wrought-iron tubes. Electrical-

resistance welded tubes are subject to deeper pitting than seamless tubes. Chromized tubes are resistant to corrosion, but they become brittle. Aluminum-coated tubes have no greater corrosion resistance than uncoated tubes. The greater resistance to pitting of wrought-iron tubes is due to the formation of the hard, compact scale on the tubes.

7. "The Residual Oil Ash Corrosion Problem," C. J. Slunder; CORROSION, v 15, November, 1959, pp 61-66.

   This is a review of progress in research on preventing corrosion caused by burning residual fuel. The methods discussed are corrosion-resistant alloys, fuel additives, and protective coatings. The basic mechanism of this type of corrosion is also discussed.

8. "Here's How to Fight Fretting Corrosion in Sheaves," E. L. Nuernberger; POWER, v 103, n 5, May, 1959, p 204.

   The solution to fretting corrosion aims at stopping the fretting; one answer is clamps. Split hubs and tapered bushings clamp sheaves and sprockets to shafts as snugly as a shrink fit and with a clamping force greater than the force causing fretting. Lubes containing graphite or molybdenum are a second answer to the reduction of fretting damage. A third approach applies materials which will not fret as shaft and hub coatings. Teflon and rubber are common examples of these coatings.

9. "Oxygen and Carbon Dioxide Corrosion," P. Brindisi; COMBUSTION, v 30, n 10, April, 1959, pp 47-52.

   Causes of corrosion problems in steam and return systems of steam power plants are discussed along with effects and occurrence. Deaeration of feedwater and other correctives, such as using sulfite and hydrazine, are covered

10. "Bibliography on the Effects of Hydrogen Embrittlement of Metals (1952 to Present)," P. E. Bell; LAMS-2283 (Los Alamos Scientific Laboratory), December 10, 1958. Available from OTS and Depository libraries.

   This title list of 108 references to reports and published literature is concerned chiefly with the effects of hydrogen on steel and titanium.

11. "Bibliography of a Decade of Research on Oil Ash Corrosion by Heavy Fuels," H. W. Schab; ASNE, v 70, November, 1958, pp 761-771.

The introduction to this bibliography contains a very good, explicit survey of the understanding of, prevention of, and research on this corrosion phenomena to date.

12. "Corrosion and Destination of Corrosion Products in High Pressure Power Plants," R. C. Tucker; CORROSION, v 14, n 5, May, 1958, pp 19-22.

Methods used to reduce corrosion are reviewed with emphasis on chemical control of boiler water and injections of potassium hydroxide and potassium phosphate. Chemical concentrations at full load are given.

13. "High-Temperature Corrosion of Alloys in the Superheater of an Oil-Fired Boiler," D. W. McDowell, Jr., R. J. Raudebaugh, W. E. Somers; ASME TRANS, v 79, February, 1957, pp 319-328.

Bunker C oil was used during the tests of the materials. An analysis of the ash constituents present in the oil-fired boiler during the tests also showed high vanadium, sulphur, sodium, and calcium contents. Corrosion results were obtained on both cast and wrought alloys as well as on some alloys with various coatings. An extensive metallographic investigation was conducted on all alloys exposed to determine the type of attack each material underwent during the exposure period.

14. "Corrosion Engineering Problems in High Purity Water," D. J. DePaul; CORROSION, v 13, January, 1957, pp 75t-80t.

A discussion of crevice corrosion and selection of materials for high purity water medium is presented.

15. "Control of Corrosion with Zinc Coatings," J. L. Kimberly; NACE, paper n 56, 1957.

This paper covers briefly the history of the uses of metallic zinc and zinc coatings to control corrosion and the basic theory under which zinc is protective to steel. Methods of application including hot-dip and electrogalvanizing, metallizing, sherardizing, and painting are outlined and discussed.

16. "Corrosion," H. P. Kallen; POWER, v 100, n 12, December, 1956, pp 73-107.

The latest corrosion-resistant metals which stand up against corrosive water, high temperatures, and chemical attack are

given. Inert barriers (silicones, epoxies, vinyls) bring corrosion to a dead stop by setting up an impregnable wall around less corrosion-resistant materials. More efficient deaeration and new inhibitors are recent developments in the water-treatment field which promise more effective corrosion control in water systems.

17. "Combating Turbine Blade Corrosion," F. H. Pennell; MAR ENGRN/LOG, v 61, April, 1956, pp 108-109.

From the point of view of brittleness of the material, the nickel-boron type offer some advantages as compared with the cobalt-chromium type for turbine blading. Both materials, in powder form (finely powdered granules), are sprayed on the surface to the required thickness, after which the powder is fused to the blade. A design for a LP turbine is given; small orifices along the lower casing drain water from the LP turbine.

18. "Sulfur Dew-Point Corrosion in Exhaust Gases," R. L. Coit; ASME TRANS, v 78, January, 1956, pp 89-94.

A selection of materials is suggested to reduce sulphur dew-point corrosion in exhaust gases on air preheaters, compressors, valves, and heat exchangers. In static tests, Hastelloy C was found to be resistant to sulphuric acid concentrations of less than 0.8. A phenolic resin to coat acid containers is most suitable for protection of copper from acid attack. A test simulating compressor-inlet conditions indicated high corrosion resistance of Type 316 stainless steel, Inconel, Carpenter No. 20, and Discaloy. In low temperature, moderate gas-velocity regions such as found in precoolers, intercoolers, and waste-heat-recovery units, Type 316 stainless steel and Hastelloy C have good acid resistance.

19. "Fretting Corrosion," R. B. Waterhouse; submitted to I MECH E for written discussion, 1955.

A general discussion is presented on how to obtain low maintenance and long life. It is emphasized that a measure which is a remedy in one case may aggravate the damage in another, indicating the need for careful diagnosis. General preventive measures given are: 1) reducing relative movement by increased friction force, increased normal load, elastic inserts; 2) reducing friction by lubrication or low friction inserts; 3) excluding the atmosphere with rubber gaskets; 4) increasing the abrasion resistance of the surfaces; 5) separating the surfaces.

20. "Corrosion of Metals in High Temperature Water at 500° F and 600° F," S. C. Datsko and C. R. Breden; ANL-5354 (Argonne National Laboratory and Babcock and Wilcox Co.), October 6, 1954, 203 pp. Available from OTS and Depository libraries.

The results of corrosion tests on a variety of metallic alloys in 500° F water are summarized. The austenitic stainless steel of the 300 series and certain types of zirconium have shown the best corrosion resistance in water. Operation of the system at 500° F with water containing at least 50 cc of hydrogen per liter permits the widest selection of materials of construction.

21. "Influence of Welding in the Cracking of Pressure Vessels," H. R. Copson; BRIT WELDING J, v 32, February, 1953, pp 90-91.

Under severe conditions caustic embrittlement, cracking associated with the presence of sodium hydroxide in the boiler, is avoided by adding inhibitors to the water. Thus, tannins, quebracho extract, waste sulfite liquor, sodium nitrate, sodium phosphate, and other additives have been beneficial. Nickel cladding has been used successfully to prevent caustic embrittlement. A full annealing and slow cooling of the fabricated pressure vessel is a dependable means of preventing stress-corrosion cracking, provided applied loads are not excessive. Painting magnesium alloys susceptible to stress-corrosion cracking has increased their life four or five times. Anodic electrodeposits have worked well. Use of sacrificial anodes which stop the corrosion has stopping the cracking in many experiments.

22. "Pad with Neoprene to Save Critical Parts from Corrosion and Wear," POWER, v 97, n 1, January, 1953, pp 103-105.

The article gives examples of the use of Neoprene coating to prevent corrosion and wear. The critical parts that can be coated include condenser tubes and tube sheet, pump impeller, heat exchanger head, large blowers, and steel valves.

23. "Protection of Ferrous Surface Against Corrosion," D. E. Antinori; GAS AND OIL POWER, v 47, n 561, May, 1952.

The tests so far carried out indicate that chromates are the most respondent to all requirements for the diesel cooling water. The best mixture seems to be that of equal parts of potassium chromate and sodium carbonate.

24. "The Application of Cathodic Protection for Corrosion Prevention,"

R. J. Sullivan; ASME TRANS, v 64, 1942, pp 809-815.

This paper presents a short review on the subject of corrosion in general. It is devoted principally to the practical applications of cathodic protection to numerous metallic structures. There are 22 references on corrosion on page 814.

DIESEL ENGINES

1. "The Development of the New Fiat 900 mm Bore Engine," Dott. Ing. A. Gregoretti; BRIT MOTORSHIP, v 41, n 486, January, 1961, p 465.

   The paper discusses the design of a 900 mm bore Fiat diesel. It describes design features which reduce vibration, lacquer formation, and outage from turbo blower failure. Some other design features are also discussed.

2. "Service Records of Mitsubishi Nagasaki" (diesel UE type engines), H. Fujita; SHIPBLDG AND SHIPG REC, v 96, n 18, November 3, 1960, pp 570-572.

   The paper deals with the various studies which are being made for the purpose of increasing the degree of supercharging, further improving reliability of the engine, decreasing the frequency of overhaul of the engine, and simplifying the handling and maintenance. Also discussed are vibration, exhaust cam, crosshead pin bearings, connecting rod oil grooves, and temperature distribution in the walls of the combustion chamber.

3. "Air-Cooled Diesels for Marine Use," SHIPBLDR AND MAR ENG BLDR, v 67, August, 1960, p 493.

   The engine is easily installed without the necessity for such equipment as heat exchangers, oil coolers, extended pipe work, and coolant circuits which are required for water-cooled engines. Air-cooling makes for quick warming up and gives an optimum running temperature over a wide range of loads.

4. "Bristol Siddeley Mayback Engines," SHIPBLDR AND MAR ENG BLDR, v 67, n 631, July, 1960, pp 429-430.

   As a result of continuous cooling, piston clearance can be reduced to a fraction of that necessary for uncooled pistons. The combination of positive cooling and minimum clearance means that these engines have a low rate of piston wear. Servicing of pistons and cylinders is made simple;

after removal of the cylinder head, the piston crown is detachable after withdrawing six bolts without taking the piston and connecting rod out of the cylinder.

5. "Development of Cylinder Water Seal to Prevent Diesel Engine Crankcase Cavitation Erosion," A. B. Neild, Jr; SAE J, v 68, n 7, July, 1960, pp 64-65.

   Studies at the U.S. Naval Engineering Experiment Station on the failure of several crankcase designs revealed that cavitation-erosion in the water seal area of an aluminum crankcase was eliminated by a wide-band cylinder-liner water seal, fabric inserts, and tough seal materials. The seal strength was made adequate for at least 3000-hour engine operational periods.

6. "Doxford's New Opposed-Piston Diesel Engine," MAR ENGR AND NAV ARCH, v 83, n 1009, July, 1960, pp 282-288.

   Features of the new design calling for attention are the simplified transverse beam carrying the load from the upper piston to the side rods, the new design of the center-top end in which a lead-bronze pad carries the firing load directly from the cross-head to the connecting rod, and the plain crankshaft bearings without spherical housing. The latter are made possible by the shorter and stiffer crankshaft which is such an important basic feature of the design.

7. "Recent Developments in the Use of Heavy Fuels in Diesel Engines on River Towboats," E. Renshaw and R. N. Larson; presented at the Great Lakes Section of SNAME, June 10, 1960.

   A description is given of how the use of a vapor phase cooling system allows efficient and economic utilization of heavy fuels in towboat diesel engines by eliminating many of the maintenance problems usually associated with the use of these fuels.

8. "Some Crankshaft Failures: Investigation, Causes and Remedies," R. Atkinson and P. Jackson; BRIT MOTORSHIP, v 40, n 476, March, 1960, pp 480-486.

   As a result of the failures of the 750 mm Doxford crankshaft, there have been many changes in design. This paper discusses those design changes which have been made to eliminate future failures.

9. "User's Problems," DEUA, paper n S267, February, 1960, pp 1-19,

20-27 (discussion).

Problems pertaining to marine, vehicle, and stationary diesel plants were treated in a symposium and discussion at a general meeting. Instrumentation and controls, maintenance and repair, bearings, cylinder liners, and injection equipment were some of the included topics.

10. "Lubrication of Free Piston Engines," GAS AND OIL POWER, v 54, November, 1959, p 303.

This is a comparison of the relative piston ring wear obtained with an early and a more recently developed free piston engine in a diesel laboratory test. Radioactive wear and engine cleanliness tests have shown the advantages of using selected high-alkaline single-phase petroleum lubricants.

11. "Ceramic Coatings for 'Hot' Diesel Components," GAS AND OIL POWER, v 54, n 657, November, 1959, pp 301-302.

The desirable characteristics provided when ceramic coatings are applied to diesel engine piston crowns, diesel valves, and cylinder heads are heat resistance up to 500° F, abrasion and electrical resistance, chemical inertness, and insulation. Use of these coatings leads to extended periods between overhauls. The results noted thus far are clean piston skirts, clean rings, and unclogged liner airports.

12. "Crankshaft Strength and Design," W. Ker Wilson; GAS AND OIL POWER, v 54, October, 1959, pp 261-264.

In bending fatigue tests, an improvement of from 16 to 32 percent was obtained by using hollow crankpins and journals in the crankshaft of a high-speed compression ignition oil engine. The same improvement was obtained when the journals were left solid and only the crankpin was made hollow.

13. "Ebullient Cooling for Towboats," MARINE NEWS, v 46, September, 1959, p 31.

The resulting uniform temperatures provide advantages over conventional engines. There is less cylinder wear and lubricating oil sludging. This naturally decreases maintenance costs while it lengthens the life of the engine. Dowtherm 209, which will azeotrope with water, proved superior in giving freeze protection both in the engine and in the condensate return line. The product has also minimized corrosion.

A 60% mixture provides freeze protection down to -80° F.

14. "High Nickel Inserts Reduce Aluminum Alloy Piston Wear," GAS AND OIL POWER, v 54, n 655, September, 1959, p 236.

Type 1 Ni-Resist iron is an ideal material for ring inserts as its thermal-expansion closely matches that of the aluminum alloy. Type 1 Ni-Resist iron withstands abrasion from the piston rings due to its excellent resistance to galling, metal-to-metal wear, and its superior strength at elevated temperatures.

15. "Steam Versus Diesel," G. Hopwood and N. W. N. Mewse; read at THE SECOND WORLD FISHING BOAT CONGRESS (Rome), April 5-10, 1959, pp 274-284.

Maintenance problems are discussed as well as maintenance techniques and procedures. Table 71, page 279, gives information about cast iron and chrome bore cylinder liner wear for 1000 hours of operation. There have been no major renewals except for the normal replacement of pistons and liners. The shell main bearings and the crankshaft are in good condition; there has been little or no wear.

16. "Service and Maintenance of Turbochargers and Turbocharged Engines," J. A. Hardy; for a meeting of the Metropolitan Section of SAE, paper n S159, March 10, 1959, 9 pp.

Factors which affect service life are considered along with the characteristics of turbocharged engines which lead to service problems. The particular subjects treated include ways to avoid over-fueling the engine, adjustments for altitude, damage caused by air leaks, and bearing play.

17. "Temperature of Cylinder Liner in Diesel Engines," THE OIL ENGINE AND GAS TURBINE, v 26, February, 1959, p 271.

High speed oil engines running on various loads suffer more wear than similar engines running on full loads most of the time. Increased corrosive wear is due to too low temperatures at part loads and can be countered by employing cooling temperatures of the order of 105°-110° C.

18. "A Contribution to the Problem of Cylinder Wear in Marine Diesel Engines," W. A. Schultze; INTERNATL SHIPBLDG PROGRESS, v 5, December, 1958, pp 566-576.

To prevent corrosive wear in chromium-plated liners, alkaline additive cylinder oils are applied. Two new methods of preventing corrosive wear are indicated by the results of this investigation. The first is the excessive lubrication of the liner; the other is to insulate the piston electrically from the piston rod.

19. "Economics of Reclamation of EMD 567 Engine Cylinders with Porous Chrome," R. Pyles and J. M. A. VanDerHorst; for a meeting of ASME, paper n 58-A-186, November 30-December 5, 1958, 9 pp.

A discussion of experiments made with a porous chrome-plated line of EMD 567 engine cylinders. The rate of wear of the unplated liner is 2.5 times that of a porous chrome-plated liner. In 200,000 miles a new cast-iron liner will have a maximum wear of 0.25 percent of bore diameter. Statistical data shows that 50 percent more use can be obtained from the chrome-plated liners than is possible under present practice. None of the porous-chrome cylinders was condemned for out of roundness. The roundness of the chrome cylinders would encourage good performance and low lube-oil consumption.

20. "Cylinder Economics with Today's Fuels, Lubricants, and Materials," R. Pyles; ASNE J, v 70, n 4, November, 1958, pp 705-718.

This paper evaluates chromium-plated cylinders specifically and cast-iron cylinders in general for use in today's engines operating on diesel, bunker C, or residual fuels. Particular reference is made to marine units, materials, wear rates, initial and maintenance costs, fuel costs, and extent of wear. It was found that chrome (porous)-plated cylinders have a life span of at least twice that of the cast-iron cylinders.

21. "Free Piston Engines," LUBRICATION, v 44, n 9, September, 1958, pp 113-132.

It is a general discussion with nothing on low maintenance except references.

22. "Metallurgical Developments for High Output Diesels," DIESEL PROGRESS, v 24, n 8, August, 1958, pp 30-31.

The use of Ni-Resist (high nickel austenitic iron) and alloys have resulted in long life and excellent dependability for the critical parts of the turbocharger. The largest size turbocharger built by Schwitzer Corp. uses D-2 Ni-Resist ductile iron for greatly improved strength

at service temperatures. The mounting of this turbocharger on the engine with no additional support simplifies engine maintenance. Cummins Engine Co. specifies type 2B Ni-Resist iron because it resists high temperature warping, scaling and corrosion, and meets the required high strength levels.

23. "Supercharging of High Powered Two-Stroke Diesel Engines," F. Schmidt; INTERNATL SHIPBLDG PROGRESS, v 5, May, 1958, pp 201-211.

A combined series-parallel operation test showed that maneuvering properties were excellent and also that the only advantage over the series process is that the engine is considerably simplified due to the absence of the auxiliary pump and the large exhaust line.

24. "The Marine Oil Engine: A Chapter in Its Progress," C. C. Pounder; INTERNATL SHIPBLDG PROGRESS, v 5, n 41, January, 1958.

The author discusses design experience and philosophy of diesel engine design with special emphasis on vibration problems and their solution.

25. "Surge of Marine Diesel Engineering," BRIT MOTORSHIP, v 38, n 452, January, 1958, pp 451-455.

Using new classes of pressure-charges, there was equal power in fewer cylinders and a consequent reduction in maintenance. Increasing cylinder size resulted in a reduction in dimensions and the number of working parts.

26. "A Single Stroke Petrol Motor," SHIPBLDG AND SHIPG REC, v 90, December 26, 1957, pp 837-838.

A new French patent of an engine using the piston principle in association with continuous rotary motion is discussed.

27. "Marine Auxiliary Generator," THE SHIPPING WORLD, v 137, September 11, 1957, pp 229-230.

Because of the low inlet temperature to the turbine in this free piston gas-generator/gas turbine unit, it is free from the corrosion problems associated with conventional gas turbines.

28. "Fourth International Congress on Combustion Engines," GAS AND OIL POWER, v 52, July, 1957, pp 155-157, 171.

In Mr. G. Camner's paper it is shown that the exhaust gas blower can be employed for scavenging and supercharging two-stroke diesel engines embodying the loop-scavenging system. The no-scavenge pump is the one of the three different forms investigated, the turbo-charger alone producing the scavenging and supercharging air. This type offers the advantages of lower fuel consumption, greater reliability in service, simpler maintenance owing to the smaller number of mechanical parts, and the noise level is reduced by the elimination of the scavenge pump and its transmission.

29. "Diesel Engine Lubricants," A. Dyson, L. F. Richards, K. R. Williams; presented at a meeting of I MECH E, May 17, 1957.

Marine engines require an oil of very high alkalinity content to reduce the severe corrosive wear and piston fouling. An alkalinity concentration of the order of 40-50 mg KOH per gram is necessary. One method of providing the necessary alkalinity, which has been very successful, is to use an emulsion of a strong aqueous solution of an alkaline material in the cylinder oil.

30. "Casting of Alloy Pistons," T. O Hunt; GAS AND OIL POWER, v 52, May, 1957, pp 122-123.

Both operating experience and laboratory engine tests with silicon alloy pistons have shown a tremendous reduction in the groove wear compared with Y-alloy. Hyper-eutectic alloys have a very low coefficient of expansion, enabling a substantial reduction to be made on cold clearances which are often comparable with those of a cast iron piston. Test pieces taken from the crown, ring belt, and boss strut sections show that in every case, both in the "as cast" and heat treated conditions, higher values are obtained from pistons cast by the chilled core method. Such castings have higher fatigue strength and greater uniformity.

31. "Piston Ring for Improved Oil Control," THE OIL ENGINE AND GAS TURBINE, v 24, April, 1957, p 445.

The inertia-flow ring has a generous peripheral area; therefore, the unit radial load is kept to a minimum. A chamfered lead-in at the edge of the upper land promotes a Michel effect. Thus, the ring always works on a fully lubricated surface with little friction or wear.

32. "Cavitation Erosion in Diesels Can Be Reduced," W. Margulis, J. A. McGowan, W. C. Leith, B. Trock, A. R. Schroder, J. A.

Joyner; SAE J, v 65, n 3, March, 1957, pp 68-70.

Suggested corrosion inhibitors are soluble oil and chromates. Some of the means of reducing cavitation erosion are reducing vibration, reducing piston clearance, increasing liner wall thickness, coating the liner surface, and plating.

33. "A Study of Piston Ring Lubrication," O. A. Saunders and S. Eilon; read at a meeting of I MECH E, January 25, 1957.

All piston rings assume a curved profile due to wear. It would appear that the adoption of a parabolic profile provides a means for improving piston-ring lubrication, reducing the amount of boundary lubrication and thereby cylinder wear. This is especially true during the running-in period. With more efficient top rings, it may be found that the number of rings per piston assembly could be diminished, reducing total piston friction.

34. "Trends in Valve Gear Design," C. Voorhies, N. Felbinger, G. R. Bouwkamp; SAE, paper n 44, January 14-18, 1957, 12 pp.

A discussion of some methods for improving the high speed operation, including the application of hydraulic lash adjusters to the diesel valve gear, is given. Cam design, push rod, valve spring, valves, and valve seats are also treated.

35. "Cooling Water for Diesel Engines," B. I. Leefer; BUREAU OF SHIPS J, v 5, January, 1957, pp 15-16.

The U.S. Bureau of Ships recommends that all diesel engines (above 500 rpm) that are cooled with fresh water shall operate within certain temperature ranges. Keeping the engine jacket water temperature above the minimum specified temperature is very important since engines that are too cold will cause extremely high cylinder wall and piston ring wear.

36. "Submarines, Snorkel and Sulfur," A. H. Fox, R. A. Pejeau, L. Raymond, L. G. Schneider; SAE, paper n 862, November 1-2, 1956, 6 pp.

At simulated snorkel conditons, high ring and liner wear appear to be principally associated with sulphur content of the fuel. Deposits are associated with the increase in exhaust back pressure and restriction of intake air. Cylinder liner bore corrosion is inversely related to the additive content of the lubricating oil. Higher additives

contribute heavier valve deposits. Results of experiments are given in tabulated form.

37. "Recent Developments in Marine Diesels," H. Carstensen; I MAR E TRANS, v 68, n 10, October, 1956, pp 365-408, 409-426.

This is a discussion of the turbocharging of the Burmeister and Wain opposed piston and poppet valve engine and on the supercharging of the Doxford engine (new simplified fuel injection gear) and a review of the principal methods of supercharging two-stroke diesel engines with respect to their relative merits. Test results of the Sulzer engine are given. Uniflow scavenging and constant gas pressure turbocharging of two-stroke marine diesels are also treated.

38. "Laboratory Tests Cut Diesel Downtime," DIESEL POWER, v 34, n 9, September, 1956, pp 46-51.

The role of laboratory tests in railroad maintenance is described. Maintenance cost reductions are cited, through the use of lubricating oil spectrographic analysis. Lubricating oil analysis is also used to maintain proper lubricating oil properties.

39. "Combating Cylinder Wear and Fouling in Large Low-Speed Diesel Engines," M. J. VanDerZijden and A. A. Kelly; I MAR E TRANS, v 68, n 8, August, 1956, pp 272-278, 278-286 (discussion).

Test results are given of an emulsion-type lubricant which reduces liner wear. This emulsion lubricant can also be applied to piston stuffing boxes on double-acting engines. When so used, it will prevent piston rod lacquering and reduce stuffing box fouling. With this lubricant, combustion chamber and exhaust valve deposits will also be reduced.

40. "Reduction of Cavitation Pitting of Diesel Engine Cylinder Liners," J. A. Joyner; SAE, paper n 760, June 3-8, 1956, 7 pp.

Light weight, high speed, turbocharged diesel engines are the objects of discussion. It was found that increasing cylinder wall thickness and control of piston clearance can reduce high frequency vibration amplitudes. This in turn reduces pitting on cylinder liners.

41. "Coolant Side Corrosion of Diesel Cylinder Sleeves---Means for Reducing," A. K. Blackwood; SAE, paper n 761, June, 1956.

Copper-chromium and nickel-chromium-molybdenum iron sleeves reduce the rate of corrosion. High relative velocity between the coolant and sleeve and deflection of the sleeve accelerate the corrosion rate. Copper-chrome gray iron reduces the corrosion rate.

42. "Operation of Marine Diesel Engines on Class 'B' Fuel," SHIPBLDR AND MAR ENG BLDR, v 63, June, 1956, pp 397-398.

Interesting data has become available as the result of the operation of a group of nine R.N. diesel engines of 9-E6 type as marine auxiliary units on class B diesel fuel. The R.N. system, the manufacturer claims, provides the best possibility of giving good service on a grade of fuel which generally does not produce the best results when used in smaller marine auxiliary units.

43. "The Doxford Engine---Progress and Development," A. Storey; read at a meeting of NECIES, v 72, March 23, 1956, pp 327-360.

The development work undertaken in the supercharging of the Doxford engine is outlined, along with a brief survey of the experience at sea. The employment of boiler fuels and the advantages to be gained are also described. A review of proposed methods of achieving mechanical simplification is included.

44. "Applications of the Deltic Engine," THE SHIPPING WORLD, v 134, February 29, 1956, pp 228-230.

The claim is made that this design of engine (opposed piston) gives the engine "great rigidity and robustness coupled with minimum maintenance requirements." Service experience seems to substantiate this claim as 5000 hours between piston examinations was found adequate.

45. "Liner Wear and Porous Chromium," J. M. A. VanDerHorst; BRIT MOTORSHIP, v 36, n 431, February, 1956, p 494.

Porous chromium-plated liners have about 2.5 times the life of cast-iron liners. When the jacket temperature was raised to 167° F, lower rates of wear were obtained on heavy oil than were found in sister ships using diesel fuel.

46. "High Speed Opposed Piston Submarine Engines," A. K. Antonsen; MAR ENGR AND NAV ARCH, v 79, n 951, January, 1956, pp 17-20.

This engine is designed around a two-crankshaft principle. The lower crankshaft is connected to exhaust pistons which control opening and closing for exhaust ports; the upper crankshaft is connected to air pistons which control air intake ports. This is a 1956 design which considered minimum comparative wear when choosing cylinder bore, piston speed, and bmep.

47. "Fiat Turbocharged Engine," BRIT MOTORSHIP, v 36, n 430, January, 1956, pp 448-450.

A new method of turbocharging the Fiat two-stroke single-acting engine (12,000 bhp) is discussed. The engine is suitable for operation on boiler oil. The fuel injection system was especially designed for this purpose, while the cooled scavenge and exhaust ports are kept free from deposit. The partition between the bottom of the cylinder liners and the crankcase prevents sludge from the cylinder walls from falling into the crankcase.

48. "Free-Piston Engines and Compressors---Bibliography," J. A. Scanlan; ASME, paper n 56-A-23.

The authors bring all pertinent references together in a single listing. This bibliography covers a literature search from 1927-1956.

49. "Investigation of Cavitation Erosion in Diesel Engine Coolant Systems," A. R. Schrader; SAE, paper n 759, 1956.

Accelerated cavitation erosion tests show that increased vibration amplitudes will cause greater amounts of cavitation; harder aluminum alloys are less damaged by cavitation than softer alloys. A neoprene coating has good cavitation resistance qualities, and engine speed has a more pronounced effect than engine load. Major frequency bands in cylinder liner vibration and cylinder block vibration for no load condition are tabulated.

50. "Cavitation Control Through Diesel Engine Water Treatment," W. Margulis, J. A. McGowan, W. C. Leith; SAE, paper n 757, 1956.

Pressure, temperature, and additives were tested with a magneto-strictive-type tester for cavitation corrosion prevention. Higher pressure (30 psi) causes less cavitation; chromate prevents cavitation when used within the limits between 1000 and 2000 ppm. Boron-nitrate is not protective up to 5000 ppm concentration; gelatine is effective in inhibiting cavitation under ambient conditions.

51. "Ebullition Cooling of Gas Engines," G. O. Bates, J. E. English, G. M. Franklin; ASME TRANS, v 78, 1956, pp 1065-1069.

Power requirements for the ebullition system are less because of the smaller fan driver and elimination of the engine-jacket water pump. Operating and maintenance costs are lower for the same reasons. Uniform heat transfer at a high rate is achieved by the turbulent boiling action, and there is little or no gradient in the temperature of the coolant. Those conditions result in less wear of the cylinders and pistons, thereby reducing piston blowby and oil sludging.

52. "Diesel Engines---Design for Service," C. H. Bradbury; DEUA, paper n S243, October 20, 1955, 24 pp.

Improvements which are being made and steps which designers are taking to reduce to a minimum the necessity for skilled attention to diesel engines are given. This paper covers the following: lubricating oil filters, injectors, valve seats, exhaust valve, cylinder rings, and piston cooling system.

53. "A Dollars and Sense Look at Liner Wear," MAR ENGR, v 60, October, 1955, pp 64-66.

Gargoyle DTE S-250 (Socony Mobil) gave reductions of liner wear in the order of 10 percent to 35 percent, depending upon the type of engine and fuel employed.

54. "Crankcase Explosions in Marine Engines," J. H. Burgoyne and D. M. Newitt; I MAR E TRANS, v 67, n 8, April 18, 1955, p 255.

This is a discussion of means of controlling and minimizing crankcase explosions. Recommendations are the result of investigations begun in 1948 and sponsored by BSRA.

55. "Silicon-Chromium Exhaust Valve Seats for Heavy Fuels," MAR ENGR AND NAV ARCH, v 78, n 941, April, 1955, pp 149-150.

Brightray-coated valves made of silicon-chromium material showed their ability to resist corrosion throughout long periods of continuous service.

56. "The Use of Heavy Fuels in Diesel Engines of Marine Auxiliary Sizes," J. Smith; INA, April 24, 1953.

A description of tests carried out on a single cylinder

engine burning residual fuels and the analysis of the results of these tests, with respect to fuel preparation and engine design, are presented.

57. "The Burning of Boiler Oil in Two and Four-Stroke Cycle Diesel Engines and the Development of Fuel Injection Equipment," A. G. Arnold; read at a meeting of I MAR E, January 13, 1953.

The design of diesel engines to burn residual fuels is discussed, while describing experience in the burning of bunker oil in five different types of diesel engines.

58. "Piston-Type Oil Engines Progress Review No. 11," I FUEL J, v 23, September, 1950, pp 266-267.

A compilation of references dealing with increasing reliability, the period between overhauls, and the normal life of components is presented.

59. The technical proceedings of a symposium of the Wisconsin-DIESEL ENGINE MANUFACTURERS ASSOCIATION, sponsored by the University of Wisconsin (Madison, Wisconsin), August 29-September 3, 1949.

Piston rings and pistons, bearing design and research, diesel fuels and lubricants, and engine operation and maintenance are discussed in detail. Fuel injection and engine cooling equipment and their related problems are covered equally well.

60. "Porous Chromium in Engine Cylinders," R. Pyles; ASME TRANS, v 66, 1944, pp 205-214.

Diesel engine cylinders and piston rings are the most critical engine parts from the wear standpoint, and in this case, porous chromium has demonstrated its ability to increase the life span of an engine. Properties inherent in porous chromium which contribute to its low wear rate in engine cylinders are hardness exceeding that of any other cylinder-lining material, high thermal conductivity, low friction coefficient and low affinity for other metals, and corrosion resistance preventing surface deterioration.

61. "Lubrication of Severe-Duty Diesel Engines," J. S. McNab; SAE J, v 49, n 2, August, 1941, pp 309-325.

Detergent-disperser inhibitors added to paraffinic base oil give better engine cleanliness and prevent the

accumulation of sludge and other contaminants on engine surfaces and on the filters (strainers). This type oil reduces engine wear by some 60% to 70% over that with the uncompounded oils. Recently developed compounded oils are in themselves non-corrosive and prevent the development of corrosive oil oxidation products.

62. "Fuels for Diesel Engines in Marine Transportation," W. F. Joachim and H. V. Nutt; ASME TRANS, v 62, 1940, pp 595-604.

The authors discuss the requirements for marine-diesel-engine fuels. A summary of engine troubles and casualties is also given. In the maintenance and wear section, a discussion is presented on combustion shock, nozzle-tip carbonization, carbon residue, sulphur, water and sediment, and wear.

63. "Wear of Diesel-Engine Cylinders and Rings," P. S. Lane; ASME TRANS, v 62, 1940, pp 95-110.

The paper considers wear mainly from the viewpoint of cylinder and ring materials. Existing wear rates in medium- and heavy-duty diesel and gas engines in various fields of service are reviewed, followed by several examples of cylinder wear as affected by the hardness and structure of the iron alloy. Initial engine wear, as influenced by bore finishes and wear-resistant or chemical surface treatments, is considered, together with the action of bimetallic or composite rings, in retarding scuffing and over-all wear rates.

64. "Diesel Deposits as Influenced by Fuels and Operating Conditions," MacGregor and Hanley; SAE J, v 43, July, 1938, p 273.

A decrease in operating temperature and load or an increase in altitude increases the quantity of deposits formed in diesel engines which are critical to fuel deposition. In these engines, increasing the average volatility or the cetane number of the fuel decreases the deposit.

65. "Gas Engines for Ship Propulsion," J. E. Thornycroft; INA, 1906.

This is a discussion of the use of internal combustion engines operating on producer gas for ship propulsion.

ELECTRICAL EQUIPMENT

1. "Rotating-Exciter Design Keeps Pace with Generator Progress," D. B. Hoover; POWER, v 104, n 4, April, 1960, p 89.

   An important innovation in the free-floating shrink-ring commutator, this construction with its free-floating bars and its thin disc centering plate permits free-bar expansion and contraction without distortion or eccentricity during temperature changes. Design features are applied to insure minimum maintenance and maximum efficiency. Large commutator exciters may be direct-, gear-, or motor-driven units. For turbine-driven generators, the rotating-rectifier excitation system eliminates brushes, commutator, and collector rings.

2. "A-C Adjustable-Speed Drive for Ships," E. G. Schroeder; MAR ENGR, v 65, n 1, January, 1960, pp 58-60.

   A-C adjustable-speed drive for ships eliminates the conventional a-c/d-c motor generator set. The absence of operating components, d-c commutators and brushes, contactors, and brakes reduces operating wear. There is a provision of infinite speed range and stepless control.

3. "The Application of Static Switching to the Control of Two 7,500 HP Oil-Fired Combustion Turbines," P. T. Carmack and E. M. Smith; AIEE TRANS, v 79, Pt II (Applications and Industry), 1960, pp 157-167.

   A partially automatic type of control of 7,500 hp oil-fired turbines is described and discussed. During starting, the distillate fuel provides a means of bringing the machines up to operating speed and temperature. Residual fuel can then be used successfully. On stopping, light fuel is used to purge the machine of the heavy fuel, thus preventing residue from forming when the turbines cool.

4. "Design and Development Problems of Radiation-Resistant High-Temperature-Tolerant Electronic Equipment Components," J. G. Stuart; AIEE TRANS, v 79, Pt II, 1960, pp 339-341.

   Electronic equipment and materials were tested to obtain a longer life in high temperature radiation fields.

5. "The Effect of Unit Size, Reliability, and System Service Quality in Planning Generation Expansion," C. J. Baldwin, C. A. Desalvo, H. D. Limmer; AIEE TRANS, v 79, Pt III, 1960, pp 1042-1048.

Digital simulation permits rapid detailed economic studies of power-system expansion problems. Curves of results have been presented for studies of the economic effect of ultimate unit size, boiler arrangement, forced-outage failure rate, and system service quality standard.

6. "Insulation System for Naval Shipboard Motors Intermittently Submerged," C. B. Hackney and H. P. Walker; AIEE TRANS, v 79, Pt III, 1960, pp 982-988.

   The article describes tests and development of a 3 hp, 1800 rpm, 440 volt, 3 phase, 60 cycle prototype squirrel-cage induction motor to operate at rated horsepower in air without exceeding the temperature limits for the insulation system and also operate at rated load while immersed in sea water without insulation failure or excessive corrosion. Electrical design, insulation design, corrosion protection, and bearings are also discussed. For the insulation, a flexible epoxy resin was found to be suitable material for encapsulating the stator windings.

7. "A New Brushless D-C Excited Rotating Field Synchronous Motor," G. M. Rosenberry; AIEE TRANS, v 79, Pt II, 1960, pp 136-139.

   The brushless synchronous motor does not require any auxiliary control for synchronizing, pull out protection, or rectifier protection. These functions are all provided by a simple, reliable circuit consisting of two silicon-controlled rectifiers and two Zener diodes. The motor can be started like an induction motor with standard induction motor starters.

8. "Factors Affecting the Aging Characteristics of Various Wire Coating Materials in Transformer Oil," G. F. Lipsey and P. W. Juneau; AIEE TRANS, v 79, Pt III, 1960, pp 73-77.

   Formex wire insulation has excellent thermal stability in a sealed system under oil; it also has resistance to hydrolysis and moisture. The data presented in this paper indicate that in a system comprised of enameled wire, cellulose insulation, an insulating oil, and varying conditions of dryness, the ability of the wire enamel to function satisfactorily is dependent upon both its hydrolytic stability and its dielectric strength characteristics in the presence of moisture.

9. "Abnormal Brush Wear in D.C. Machines," BUREAU OF SHIPS J, v 8, July, 1959, p 25.

Any amount of any type of silicone varnish, compound, rubber, grease, laminate, or binder will cause abnormal brush wear and must be avoided in enclosed d-c machines or enclosed a-c machines having collector rings within the machine enclosure. Even minute amounts of silicone vapor are absorbed in the carbon brushes, the silicone then being converted by the arcing under the brush face to a sand-like abrasive material.

10. "Design of Electro-Mechanical Auxiliaries Directly Associated with Power Producing Reactors," A. E. Howard, P. Scott, B. H. Stonehouse; IEE PROC, v 106, Pt A (Power Engineering), n 27, June, 1959, pp 262-270, 270-276 (discussion).

    Control rods, materials used, design, operation, and an approach to low maintenance are considered. Discussion is from the point of view of reliability and low maintenance.

11. "New Adjustable-Speed Squirrel-Cage Motor: What Does It Promise?," E. R. Laithwaite; POWER, v 103, n 1, January, 1959, p 78.

    A squirrel-cage motor with speed that can be adjusted continuously without an additional regulator or resistor has been invented. A big feature is its simplicity of installation and maintenance. Stator bore and rotor core are spherical rather than cylindrical, permitting rotor and stator axes to be inclined with respect to each other. This makes the speed variation possible.

12. "Factors Influencing Starting Duty of Large Induction Motor," V. J. Picozzi; AIEE TRANS, v 78, Pt IIIA, 1959, pp 401-407.

    The motor may be limited by either the rotor or stator heating during the starting period. For motor protection to be complete, the motor must be protected during the stalled condition and the accelerating period as well as at moderate running overloads. The Nema table defining safe load WK^2 for given horsepowers and speeds represents a basis of good application. Table 1, page 403, gives load WK^2 for polyphase squirrel-cage induction motors larger than 200 hp up to 2500 hp.

13. "A Novel Type of Smoothly Variable Speed, A-C Motors Having Widely Adjustable Power-Factor Characteristics," P. K. Charlu; AIEE TRANS, v 78, Pt IIIA, 1959, pp 407-413.

    It is a versatile machine capable of being adapted to single-phase and polyphase systems. The brush and

commutator wear is negligible when the armature is rotated approximately at synchronous speed in the direction of rotation. It would be better to provide direct drive to the brush carriage by providing trunnion bearings on the commutator end and making the brush-drive motor as an overhang similar to alternator exciters.

14. "The Establishment of a Base for Class A Random-Wound-Motor Insulation Life by AIEE Standard No. 510 Test Procedure and Its Correlation with Field Experience," R. L. Balke and D. R. Blake; AIEE TRANS, v 78, Pt IIIA, 1959, pp 660-665.

Two systems were tested. System Y is the system selected and currently being evaluated by the working group. System Z is the system that has been in industry from 1941 to the present. Surge test failure gave an extrapolated life of 11.5% shorter than that predicted from actual life for system Y, while it was 9.3% greater for system Z.

15. "A Hydrostatic Thrust-Type Shaft Seal for Hydrogen Cooled Generators," W. W. Gardner, A. Lehrkind, W. L. Ringland; AIEE TRANS, v 78, Pt IIIA, 1959, pp 653-659.

Seals of the size of generators tested as well as larger sizes are being applied on 3600 rpm machines. Much larger seals are being applied on an 1800 rpm conductor-cooled machine. Also, these applications are for machines suitable for operation at more than 30 psi hydrogen pressure. Oil film pressure is only slightly higher than the hydrogen pressure; bearing pressure on the babbitt seal face is very conservative for all foreseeable hydrogen pressure requirements. Oil film pressure adjusts itself automatically for changing hydrogen pressure.

16. "A Variable-Speed Reversible Drive Using an Induction Motor," G. Hansen, P. P. Biringer, G. R. Slemon; AIEE TRANS, v 78, Pt IIIB, 1959, pp 1549-1554.

The paper describes a drive in which a wound-rotor induction motor is supplied through a static-magnetic power modulator. The drive provides accurate, continuously variable control of speed at any setting up to synchronous speed in either direction of rotation. It is stated that all the components of the drive are highly reliable and require a minimum of maintenance.

17. "Contact Erosion on a Capacitor Switch," V. E. Phillips, J. C. Sofianek, A. L. Streater; AIEE TRANS, v 78, Pt IIIB, 1959, pp 1692-1697.

A program is outlined to determine the relative severity of circuit characteristics and to develop means for quantitatively relating the significant circuit characteristics to the contact erosion of a capacitor switch designed for the practical maximum life. Predicting load-life characteristics of capacitor switches in distribution circuits is also treated.

18. "Static Excitation System for Marine Auxiliaries," MAR ENGR AND NAV ARCH, v 81, June, 1958, pp 219-220.

    Replacement of rotary exciters by the Accurex static system reduces maintenance. This is used for marine auxiliary alternators for fast and accurate voltage regulation, having no moving parts.

19. "New Brush Holder," GAS AND OIL POWER, v 53, n 635, January, 1958, p 27.

    This new design of brush holder and pressure finger has the advantages of lengthening the period between successive reconditioning of the motor commutators five to ten times and almost doubling brush life.

20. "NEL Reliability Bibliography Supplement I," W. E. Jorgensen, G. Carlson, C. G. Cros; BUREAU OF SHIPS (Navy Electronics Laboratory, San Diego, California), PB-121838-S, 1958, 174 pp. Available from OTS.

    A survey was made of world-wide published literature dealing with the reliability of electronic components and circuits; 616 annotated references are given.

21. "Five Years Experience on the Consolidated Edison System with Protection of Turbine Generators and Boilers by Automatic Tripping," W. C. Beattie, H. A. Bauman, J. M. Driscoll, P. T. Onderdonk, R. L. Webb; AIEE TRANS, v 77, Pt III, 1958, pp 1353-1359.

    The paper discusses the development of a protective system for conditions of excessive differential expansion and instantaneous thrust-bearing failure under impact loading. The trip of the unit as related to motor-driven boiler feed pumps has been designed for a low level in the oil reservoir, loss of lubricating oil pressure in the hydraulic coupling drive for a shaft-driven boiler feed pump, excessively high and low boiler water drum level, and excessive rates of metal temperature change.

22. "Design Features and Characteristics of Large Steam Turbine Generators," S. C. Barton, J. A. Massingill, H. D. Taylor; AIEE TRANS, v 77, Pt III, 1958, pp 1335-1345.

Conductor cooling for both rotor and stator windings is reviewed briefly. The reliability of very large generators has been considerably enhanced by the development of Micapal, a greatly improved high-voltage insulation for stator coils. Progress in the improvements of the mechanical operation of rotors, balancing techniques, predetermination of critical speeds, improvement and simplification of hydrogen systems, and new techniques in precautionary practices to guard against gas explosions is discussed.

23. "An Advanced Concept for Turbine-Generator Stator-Winding Insulation," E. J. Flynn, C. E. Kilbourne, C. D. Richardson; AIEE TRANS, v 77, Pt III, 1958, pp 358-365.

A new type of turbine-generator bar ground insulation has been developed which uses a mica mat as the predominant dielectric material, modified epoxy resins as the binding, an impregnating agent, and woven glass tape as the supporting member. It is physically much stronger and tougher than any previously available system. It has high dielectric strength, longer high-voltage endurance, and lower dielectric loss than systems which have proved their adequacy by long service. Its thermal endurance, both to very high and very low temperatures, gives assurance of long life and great resistance to deterioration.

24. "Metallic Rectifiers for D.C. Power from A.C. Plants," N. Horowitz; BUREAU OF SHIPS J, v 6, May, 1957, pp 20-22.

The rectifier is located close to the equipment for which it is to be used. This has obviated the need for a d-c section of ship service switchboard and d-c distribution system. Having no moving parts, it can operate silently and maintenance is simple.

25. "Light-Weight Anodized Aluminum Wire for Electric Motors, Etc.," SHIPBLDR AND MAR ENG BLDR, v 63, May, 1956, p 343.

Electrical equipment wound with light, heat-resistant aluminum wire can be made smaller, cheaper, and lighter and can run hotter. Aluminum oxide, which is built up by anodizing, is an insulator that maintains its insulating properties at very high temperatures.

26. "Today's Electric Motors Major Key to Modern Industrial Growth,"

J. J. O'Connor; POWER, v 99, n 6, June, 1955, p 73.

New insulations having longer life and the elimination of regreasing to obtain maintenance-free bearings for electric motors are discussed.

27. "Report of the Investigation of Two Generator Rotor Fractures," C. Schabtach and E. L. Fogleman; ASME, paper n 55-A-208.

Investigation showed the two bursts were caused primarily by unusual and severe stress concentrations, combined with characteristics of the materials from which the rotors were made. Improved practices to eliminate particular differences which were the major causes of the two bursts were introduced.

28. "Protection of Industrial Plants Against Insulation Breakdown and Consequential Damages," H. R. Vaughan; AIEE TRANS, v 65, August-September, 1946, pp 592-596.

There are methods available for surge protecting almost any combination of circuits and apparatus that may be encountered in industrial plants. Consequential damages due to high transient voltages, resulting from unavoidable ground faults, can be prevented by proper neutral grounding. Experience has shown that trouble from electrical failures has been reduced to a minimum when these precautions are taken.

FUELS

1. "Washing Bunker C Fuel Oil---An Answer to Slag and Corrosion?," W. A. Walls and W. S. Proctor; COMBUSTION, v 31, April, 1960, pp 43-45.

The article offers water washing of Bunker C oil as a solution to slag and corrosion. After studying the experience and methods used for other applications and examining the composition of slags from Atlantic fleet boilers, a major reduction in the sodium level of the bunker fuel might offset the effect of vanadium content and result in decreased slagging. Being in the form of water-soluble salts, much of the sodium content could be removed by washing. A recently-installed Bunker C fuel-washing system in the SS ATLANTIC SEAMAN represents this technique for slag reduction on a vessel with oil-fired boilers.

2. "Experimental Investigation of Fuel Additives in a Supercharged

Boiler," R. J. Zoschak and R. W. Bryers; ASME TRANS, SERIES A, J OF ENGINEERING FOR POWER, v 82, 1960, pp 169-180.

To permit the use of high-vanadium residual oil as fuel for combined supercharged-boiler gas-turbine power plants, it is necessary to determine the treatment required to prevent the high-temperature corrosion and deposit problems associated with this fuel. The results thus far obtained are presented together with some hypotheses regarding the formation of deposits.

3. "Fuel Problems in Merchant Ships," W. McClimont; I FUEL J, v 32, May, 1959, pp 225-231.

The paper discusses vanadium and sodium content, influence of shipboard stowage practice, sludge formation, boiler problems including spalling and ash deposits, and corrosion problems connected with the use of this fuel.

4. "Sharples DHM Nozljector Continuous-Sludging Centrifuge," MAR ENGR AND NAV ARCH, v 81, n 985, September, 1958, pp 345-346.

The main advantages of the purifier are that it was designed for this specific application and that it has no valves or moving parts in the bowl. It is continuous in operation and needs no attention except for the periodic dumping of the concentrated sludge.

5. "The Effect of Treated High-Vanadium Fuel on Gas Turbine Load, Efficiency, and Life," B. O. Buckland; ASME, paper n 58-GTP-17.

The effect of high-vanadium fuel on the life of parts of gas turbines is discussed. A suggestion is made for indefinite continuous operation of gas turbines with the use of a catalyst.

6. "How Additives Can Make Your Residual Fuels Burn Better, Cleaner," R. S. Norris; POWER, v 100, n 8, August, 1956, p. 120.

The wear and corrosion problems of diesel engines, gas turbines, and steam boilers created by the sulphur, vanadium, and sodium content of residual fuels may be reduced with the proper additives.

7. "Fuel Oil Additives," THE SHIPPING WORLD, v 134, January 11, 1956, pp 43-44.

Engine and liner wear can be reduced by neutralizing the effect of highly destructive sulphurous gases formed during combustion. Additives facilitate the use of heavier, cheaper fuel oils. A discussion is given on the beneficial effects of certain additives.

8. "Fuels for U.S. Navy Gas Turbines," H. F. King and H. V. Nutt; ASME TRANS, v 78, January, 1956, pp 185-196.

Fuel additives suggested to prevent corrosion and fouling are magnesium, silicon compound, oil-soluble calcium, zinc, and aluminum compounds. An oxide coating was found more desirable than glassy ceramic coatings for corrosion resistance. Promising materials unattacked by synthetic mixtures at 1600° F are chromium metal, alumine, thoria, spinel, and two cermets. Cosag fuel specifications and requirements are given, along with a discussion of residual fuel in base-load engines.

9. "Modified Residual Fuel for Gas Turbines," B. O. Buckland and D. G. Sanders; ASME TRANS, v 77, November, 1955, pp 1199-1209.

Sodium in gas turbine fuel causes rapid deposit formation as well as corrosion. Besides naturally contained sodium, sea water contamination during transportation introduces additional amounts. In order to obtain the benefits of low sodium fuel, 90% or more of the sodium is washed out of the fuel by a scheme described.

10. "Burning Bunker Oils in American Diesels," E. B. Rawlins, E. D. Newell, D. C. MacMillan; MAR ENGRN/LOG, January-February, 1952.

The paper discusses in some detail the choice and preparation of residual fuels and the design of fuel systems which would permit the efficient and economic use of bunker fuels in marine diesel engines.

11. "Some Aspects of the Application of Residual Oils as Fuel for the Gas Turbine," C. F. Kottcamp and L. O. Crockett; ASME, paper n 50-A-131.

The author describes the development of residual oils in the typical refinery and discusses some of their properties. The application of No. 6 fuel oil to the combustion process of gas turbines is primarily that of fuel-oil atomization and combustion chamber design.

GAS TURBINES

1. "Marine Gas Turbine Free Piston Gas Bibliography," J. W. Sawyer; ASNE J, v 72, n 3, August, 1960, pp 565-584.

   This bibliography covers technical papers and press releases during the period 1958-1959. The references are to gas turbines for both ship propulsion and auxiliary service. The articles have been abstracted and a subject index prepared.

2. "Gas Turbines---Demonstrated Ability," J. W. Sawyer; ASNE J, v 71, n 3, August, 1959, pp 529-534.

   The initial cost, maintenance cost, availability, overhaul interval, and reliability of gas turbines are given with specific references.

3. "Marine Gas Turbine Progress," J. W. Sawyer and H. M. Simpson; BUREAU OF SHIPS J, v 7, n 10, February, 1959, pp 6-15; v 7, n 11, March, 1959, pp 5-13; v 7, n 12, April, 1959, pp 6-11.

   A general discussion, with many references, of marine gas turbine and free piston progress during the period 1953-1957 is given. Different applications in different power ranges and the problems associated with those applications are also treated.

4. "Symposium on Gas Turbine Sea Experience," ASNE J, v 71, n 1, February, 1959, pp 43-56, 56-61 (discussion).

   This is a four-paper discussion on the operation experience of gas turbines. 1) Operating experience with U.S.N. gas turbines at sea revealed that the application of gas turbines is a good practice in minesweepers. A recommendation was made for the improvement of turbine blades with precision castings instead of forged and machined ones. 2) Operating experience with the GTS JOHN SERGEANT resulted in the suggestion for fuel washing with fresh water and adding magnesium to reduce sodium and vanadium. 3) Some marine propulsion and generator set applications were tested to prevent corrosion of rotor blades made from 12-chrome steel. The cooling air problem was solved by bringing the cooling air through the center of the compressor drum, through the turbine shaft, and then to the turbine wheel. Thus, the rotating air seal which was quite a problem was eliminated. 4) Efficiency, fuel consumption, and operation are discussed.

5. "1959 Gas Turbine Progress Report---Marine," J. W. Sawyer and H. M. Simpson; ASME TRANS, SERIES A, J OF ENGINEERING FOR POWER, v 81, 1959, pp 311-343.

This is a review of gas turbine and free piston developments up to 1959. The different types of gas turbine cycles and operation experiences are discussed with some given solutions for the troubles.

6. "Effect of Prior Air Force Overtemperature Operation on Life of J47 Buckets Evaluated at Sea-Level Cyclic Engine Test," R. A. Signorelli, J. R. Johnston, F. B. Garrett; NACA, Technical Notes 4263, April, 1958, 41 pp.

The effects of various heat treatments on the life of overtemperatured buckets are investigated. Full reheat treatment of overtemperatured buckets has increased resistance to leading-edge cracking and improved stress-rupture life.

7. "Control of Marine Gas Turbine," F. H. VanNest; ASME, paper n 58-GTP-10, March 2-6, 1958, 12 pp.

The problems involved in adapting the turbine to marine service are treated, with specific reference to GTS JOHN SERGEANT. The variable-area load-turbine nozzle is well suited to marine service. The reliability of this engine is as good as or better than any other type of marine engine.

8. "Operating Experience of General Electric Gas Turbines," H. D. McLean; ASME, paper n 58-GTP-18, March 2-6, 1958, 26 pp.

First stage bucket life is increased by a special heat treatment involving double aging. Thrust bearing failure was eliminated by increasing the effectiveness of the active thrust bearing in carrying the high static load. Compressor inlet guide vane failure was eliminated by using shrouded guide vanes. Heat shock failure was reduced by arranging a new starting control system. Fuel treating was accomplished by removing the sodium and calcium by washing. Second stage bucket failure due to fatigue and vibration was eliminated by the use of crucible 422 alloy instead of Timken material. The future trend is to build large, simple-cycle, one-shaft gas turbines.

9. "Marine Gas Turbine, Free Piston Gas Turbine Bibliography," J. W. Sawyer; ASNE J, v 70, n 1, February, 1958, pp 159-169.

Summaries of 108 papers on design, selection, building, and operation of marine gas turbines are given. These have been arranged by years, beginning with 1952 and extending through 1957.

10. "Design and Development of Four Light-Weight High-Speed Marine Gas Turbines for Electric Generator Drive," A. W. Pope; I MECH E, v 172, 1958, pp 301-319.

This paper deals with the six most outstanding problems that were encountered during the design and development of the turbines. These problems are related to centrifugal compressors, high-pressure turbine, governing of a compound gas turbine alternator, flexible bearings, turbine casing, and small axial flow compressors.

11. "The Auris Gas Turbine Project," J. Lamb and L. Birts; ASME, paper n 58-GTP-12.

The results of the experience with the 1200 hp gas turbine and improvement of design for the new 5500 hp cycle considering the working state, materials selected, increasing the life of components, and component failure are described. A discussion of the new 5500 hp turbine includes a general outline, machinery arrangement, turbine cycle, LP compressor, intercooler, air ducting, HP compressor, HP turbine, LP turbine, heat exchanger, combustion chamber, burners, starting steam turbine, transmission and control system, lubricating oil system, fuel system, propulsion control, electrical system, and waste-heat boiler.

12. "Accelerated Life Tests of a Pair of Naval Gas Turbines," J. S. Pasman, C. L. Miller, S. E. Fisher; ASME, paper n 58-GTP-7.

This is a discussion of a Boeing 502, 160 hp split-shaft engine with a centrifugal compressor, driven by a single-stage axial-flow turbine rated at 36,000 rpm. A summary of the new components used in the test is given; these include a modified combustor, first-stage turbines containing blades with a 0.6 inch chord, quick-disconnect burner elbows (permitting easy combustor removal for inspection), improved spark plugs, high temperature O-rings on the fuel governor-control arm, and bronze helical-drive gear for lube oil pump. A listing of difficulties experienced during 2500 hours of testing in two Boeing 502-6 gas turbine engines is presented. The results of this test indicate that a 1000-hour overhaul period is feasible.

13. "Shipboard Gas Turbine Engine Tests," P. W. Pichel, D. E. Blackwood,

W. P. Henry; MECH ENGRN, v 79, December, 1957, pp 1119-1122.

Objectives of the accelerated service test were demonstration of reliability and low maintenance requirements, establishment of future maintenance and overhaul schedules, and obtaining improved durability and performance information. Compressor-inlet guide vanes are made from rolled vane stock rather than sheet metal. Carboblast cleaning material is a simple and effective tool against compressor blade fouling.

14. "Operating Experience and Design Features of Closed-Cycle Gas-Turbine Power Plants," C. Keller; ASME TRANS, v 79, n 3, April, 1957, pp 627-643.

The regulating procedure of closed-cycle plants is made quite simple by combining pressure-level variation with by-passing the compressor. Inlet, outlet, and bypass valves for the working medium are in the cold region. Charging and leakage compressors' reliability is improved by using rotary Lysholm-type compressors. The turbine and compressor are built on the same shaft with Tuco-set, reduced leakage losses, and no need for high-pressure glands.

15. "Westinghouse New Single Shaft 3000 hp Gas Turbine Ideal for Mechanical Drive Applications," J. Yindra; ASME, paper n 57-GTP-12, March 18-21, 1957.

The 3000 hp, 8500 rpm, single turbine-compressor rotor unit requiring two end bearings outside of the gas stream for an industrial plant is described from the design, maintenance, and operational point of view. Locating the bearings outside the gas stream minimizes the effect of external misalignment. With the elimination of high-pressure seals, no external leakage of gland air occurs from the cycle. To facilitate maintenance, a single horizontal joint is provided on the compressor, combustor, and turbine covers.

16. "Some Problems in Design and Use of Free-Piston Gas Generators on Board Ships," M. A. Augustin-Normand, Jr. and M. Barthalon; INA TRANS, v 99, 1957, pp 157-167, 167-170.

A complete discussion from various sources is presented of installation, performance, and operation problems of the free-piston/gas-turbine propulsion system with some emphasis on designing for reliability.

17. "Seal Leakage in the Rotary Regenerator and Its Effect on Rotary-Regenerator Design for Gas Turbines," D. B. Harper; ASME TRANS, v 79, 1957, pp 233-245.

The best over-all rotary-regenerator arrangement will have a rotor containing the matrix and a system of rotating, compartmented ducts leading out to small seal shoes.

18. "Design Considerations for Marine Gas Turbines," F. R. Spurrier; ASME, paper n 57-GTP-7.

Multiple engines of basically simple design can be employed for improved reliability by virtue of the simplicity of the individual units. Blade root design is changed to fir-tree fixing; simple sleeve-type bearings are used.

19. "British Navy Makes Good Use of Gas Turbine," L. Walter; BRIT MOTORSHIP, v 41, n 7, July, 1956, pp 30-33.

A discussion is presented of the naval use of gas turbines, the advantages claimed for smaller craft, and the future needs for gas turbines to be a naval prime mover.

20. "Free Piston Gas Generators at Cherbourg," ENGINEER, v 201, n 5236, June 1, 1956, p 301.

French naval minesweepers are described which are powered with two sets of gas turbines, each powered by one GS-34 free piston gas generator and each delivering 1000 hp at the propeller shaft. The gas turbines run at 9000 rpm and drive the propeller at 500 rpm through reduction gearing. Controls consist of a three-way valve at the turbine operated by a servo-motor at the control position and an injection pump control. To move ahead or astern, the controls are adjusted to close the inlet to astern or ahead turbines, respectively.

21. "Free Piston Gas Generator," R. Huber; ENGINEERING, v 181, n 4706, May 18, 1956, pp 371-373.

For the free piston gas system, the temperature and pressure are moderate. Due to these operating conditions, there is no corrosion trouble from vanadium. Mechanical vibrations are very slight. As regards frequency of inspection and maintenance requirements, experience indicates the turbine can run satisfactorily 20,000-25,000 hours without overhaul. The precombustion chamber and moving parts have to be examined at every 3000 hours; injectors have to be undertaken after every 1500 hours. No adjustment of the oil and cooling water system is necessary.

22. "Free Piston Gas Generators and Their Applications," E. S. L. Beale and P. Watson; DEUA, paper n S246, May, 1956, pp 1-30.

These engines require no special attention in heavy weather. When the propeller comes out of the water in a heavy sea, the gas generators are unaffected and continue to run at the speed and stroke required and no adjustment of the oil and water cooling system is necessary.

23. "Standard Gas Turbine for Variety of Fuels," G. B. R. Feilden, J. D. Thorn, M. J. Kemper; read at a meeting of I MECH E, April 6, 1956.

The authors have found that the elbow chamber has maintained its original promise in practice of mechanical simplicity, accessibility, and economy and is proving itself suitable for a wide range of different fuels.

24. "Installation, Maintenance of Gas Turbines," H. H. Horak; BUREAU OF SHIPS J, April, 1956, pp 15-16, 18.

The installation of two 4000 hp marine gas turbines in a PT boat (USN) is discussed and a description given of the operating difficulties encountered in the operation of similarly equipped British patrol boats. Improvements in operating reliability brought about by design changes are also discussed.

25. "Gas Turbine for Mobile Power Unit," F. O. Hennig; ASME, paper n 56-GTP-14.

This paper offers a detailed description of design features developed for the mobile power unit. It also covers considerations of flexibility necessary to make this gas turbine suitable for other applications.

26. "Increased Life for Gas Turbine Combustion Systems Burning Residual Fuel," R. W. Macaulay and G. M. Gardiner; ASME, paper n 56-GTP-11.

This paper describes a new type of liner and fuel nozzle which, on the basis of limited field experience, have shown improved life with fewer changes. It also gives a brief review of test data and operating experience on combustion liners and fuel nozzles.

27. "33,000 Hours on Marine Gas Turbines in Naval Service," W. M. M. Fowden, Jr. and J. W. Sawyer; ASME, paper n 56-GTP-7.

After some 33,000 hours of operating experience with marine gas turbines in naval vessels, the reliability, economy, ease of operation, and quick replacement of this type of prime mover may be considered well established. Details of experience gained in the operation of the various units in service are gas turbine marine application for 250 kw emergency generator set, 500 hp auxiliary generator drive, 160 hp mine sweep generator drive, 160 hp mine sweep propulsion drive, 160 hp auxiliary generator drive, 50 hp pump drive, and 160 hp deicer.

28. "Design Considerations for Naval Gas Turbines," G. L. Graves, Jr.; ASME, paper n 56-GTP-1.

For a booster or peak-load engine, a single-spool engine with a free-power turbine provides simplicity. The advantages of a multiengined plant from the point of view of ease of maintenance and simplicity of replacement of parts are discussed. Component design considerations are given for compressor, combustion chamber, turbines, ducting, intercoolers, regenerators, and waste-heat boiler.

29. "The Gas Turbine---A Versatile Servant for the Process Industries," W. B. Wilson; AIEE, paper n 56-425.

This paper discusses the fuels best suited for use in the gas turbine, lists data on the hours of operating experience and reliability of gas turbines now in service, discusses the size ranges available, and shows the ability of gas turbines at elevated pressure and temperature to utilize surplus gas available from some processes.

30. "Fuels for U.S. Navy Gas Turbines," H. F. King and H. V. Nutt; BUREAU OF SHIPS J, v 4, October, 1955, pp 9-12.

A program was initiated to determine the effect of salt water entrained in diesel fuel on turbine deposits and corrosion. A series of short tests, in which fuel containing up to 0.5% sea water was used, indicated that sea water contamination should be avoided.

31. "A Novel Cooling Method for Gas Turbines," E. Burke and G. A. Kemeny; ASME TRANS, v 77, 1955, pp 187-195.

Water (or some other liquid coolant) is sprayed to the rotor blades and forms a layer which serves both to insulate the blade from the hot gas stream and to extract heat from the blade. Results of experiments on a supercharger, with gas temperatures between 1150° F and 2350° F,

After some 33,000 hours of operating experience with marine gas turbines in naval vessels, the reliability, economy, ease of operation, and quick replacement of this type of prime mover may be considered well established. Details of experience gained in the operation of the various units in service are gas turbine marine application for 250 kw emergency generator set, 500 hp auxiliary generator drive, 160 hp mine sweep generator drive, 160 hp mine sweep propulsion drive, 160 hp auxiliary generator drive, 50 hp pump drive, and 160 hp deicer.

28. "Design Considerations for Naval Gas Turbines," G. L. Graves, Jr.; ASME, paper n 56-GTP-1.

For a booster or peak-load engine, a single-spool engine with a free-power turbine provides simplicity. The advantages of a multiengined plant from the point of view of ease of maintenance and simplicity of replacement of parts are discussed. Component design considerations are given for compressor, combustion chamber, turbines, ducting, intercoolers, regenerators, and waste-heat boiler.

29. "The Gas Turbine---A Versatile Servant for the Process Industries," W. B. Wilson; AIEE, paper n 56-425.

This paper discusses the fuels best suited for use in the gas turbine, lists data on the hours of operating experience and reliability of gas turbines now in service, discusses the size ranges available, and shows the ability of gas turbines at elevated pressure and temperature to utilize surplus gas available from some processes.

30. "Fuels for U.S. Navy Gas Turbines," H. F. King and H. V. Nutt; BUREAU OF SHIPS J, v 4, October, 1955, pp 9-12.

A program was initiated to determine the effect of salt water entrained in diesel fuel on turbine deposits and corrosion. A series of short tests, in which fuel containing up to 0.5% sea water was used, indicated that sea water contamination should be avoided.

31. "A Novel Cooling Method for Gas Turbines," E. Burke and G. A. Kemeny; ASME TRANS, v 77, 1955, pp 187-195.

Water (or some other liquid coolant) is sprayed to the rotor blades and forms a layer which serves both to insulate the blade from the hot gas stream and to extract heat from the blade. Results of experiments on a supercharger, with gas temperatures between 1150° F and 2350° F,

permit a simpler design and greater reliability than appears possible with the other cooling methods. Furthermore, the optimum blade-temperature distribution probably can be achieved more readily

32. "The Development of a 500-hp Multipurpose Gas-Turbine Engine," P. G. Carlson; ASME, paper n 55-S-36.

    Under the sponsorship of the Bureau of Ships, a program was undertaken to redesign engine components found troublesome in the T-400J unit, increase power output and thermal efficiency, and extend engine running time to prove the reliability of the modified unit.

33. "Fuel Systems and Controls for Marine Gas Turbines," R. F. Darling; I MECH E PROC, v 168, 1954, pp 159-165.

    It is emphasized that reliability is by far the most important requirement in the control system of a marine power plant. The sprayers, control blocks, fuel system, transmission, reversing mechanism, and governors are described in turn. The reasons are given why various features were adopted in preference to the possible alternatives.

34. "The Influence of Some Chemical and Physical Factors on the Formation of Deposits from Residual Fuel," P. T. Sulzer; ASME, paper n 54-A-171.

    The oil-ash deposit problem in industrial gas-turbine plants is analyzed in this paper from both physical and chemical standpoints. Measurements of ash-deposit formation as a function of temperature, pressure, excess air, fuel-ash content, and test durations are shown graphically and summarized in a formula.

35. "Review of Optimum Design of Gas Turbine Generators," D. Aronson: ASME, paper n 51-A-107.

    The paper summarizes design relationships as a means of simplifying design and selection of the most suitable regenerator for a particular gas turbine application. Criteria are presented for shape, volume, weight, or surface area---whichever is the principal limitation. The distinctive features of bare tube design and extended surface are outlined.

36. "The Applicability of Ceramics and Ceramals as Turbine-Blade Materials for the Newer Aircraft Power Plants," A. R. Bobrowsky; ASME TRANS, v 71, 1949, pp 621-629.

Ceramic and ceramal materials have been investigated for use as turbine-blade materials. Tensile, flexure, thermal shock, and oxidation data for these materials at temperatures up to 2400° F are presented. Data are discussed with respect to applicability for turbine use. Carbide-base materials possess good thermal shock resistance and operate cooler than most high-temperature alloys, but they may present oxidation problems.

37. "Hot-Spin Tests of Bladed Jet-Engine Rotors," H. B. Saldin and P. G. DeHuff, Jr.; ASME TRANS, v 71, 1949, pp 605-612.

Out of four disks tested, the standard 19-9-DL showed the best combination of strength and ductility, although the Timken 16-25-6 material as processed was slightly stronger than the standard 19-9-DL.

38. "Nickel-Chromium Alloys for Gas-Turbine Service," C. A. Crawford; ASME TRANS, v 69, 1947, pp 609-612.

Inconel X for wrought forms and the heat-treated 50-nickel-20-chromium alloy in cast forms offer a useful combination of properties for components of aircraft gas turbines and for application to ship propulsion. The cast form is primarily suited for extended service applications requiring high creep resistance in the neighborhood of 1500° F.

GEARS

1. "Experience with Hardened and Ground Gearing in the Royal Canadian Navy," D. K. Nicholson; I MAR E (Canadian Division), June, 1961.

This is a discussion of the RCN's experience with manufacturing hardened and ground gears. These were given some service experience and the test results are described. They claim the maximum of reliability for hardened and ground gearing.

2. "Performance Tests of Water-Lubricated Bearing Materials for Condenser-Circulating Pumps," F. L. Yetter; AM POWER CONFERENCE, 1960.

Tests showed that the carbide family is far superior to any other type of material evaluated. Wear was very low and, after a break-in period, the increase was practically nil. A combination of metal bearings and carbide journals also gave long life and low wear because of the carbides' nongalling action. Of the other materials used for

condenser-circulator bearings, leaded bronze and "filled" Teflon running on stainless-steel journals showed up best.

3. "Marine Gears, Present Position and Future Development," C. G. Wahl; BROWN BOVERI REVUE, v 46, n 8, August, 1959, pp 435-442.

   The nitriding process for hardening gears will increase their reliability. Unhardened marine gearwheels are often subject to pitting, particularly with large face widths where local overloading is not always avoidable. This problem is reduced with hardened gears.

4. "High Torque Merchant Ship Gearing," J. R. C. Braddyll and M. C. Oldham; ASNE J, v 71, n 3, August, 1959, pp 521-528.

   For high torques (25 x 10^6 lb. in.), a twin-turbine arrangement using dual tandem gearing having hardened first-reduction units is desirable.

5. "Design and Service Experience with United States Naval Gears," W. W. Braley and M. S. Berg; SHIPBLDG AND SHIPG REC, v 92, n 13, September 25, 1958, pp 406-407; v 92, n 14, October 2, 1958, p 442.

   A recent design of reduction gear features high-pressure and low-pressure steam turbines driving the two high-speed pinions through flexible couplings. Each high-speed pinion drives two "intermediate assemblies," each consisting of a high-speed gear connected to a low-speed pinion through a quill shaft and flexible couplings. The life of these turbine-pinion gear couplings doubled when 240 bhn (minimum) material replaced 160 bhn material.

6. "What Causes Failure of Today's Gears?," E. S. Reynolds; POWER, v 102, n 4, April, 1958, p 120.

   A general discussion of five basic causes of gear-tooth failure is presented. They are original surface roughness, mechanical damage, abrasive contaminant in the lubricant, metal failure, and lubrication.

7. "Can Hydraulic Couplings Double as Feedwater Regulators?," I. J. Karassik; COMBUSTION, v 29, n 6, December, 1957, pp 34-37.

   The feedwater regulator valve may be eliminated if a boiler feed pump installation embodying a hydraulic coupling is used.

8. "Improved Electric Couplings," WESTINGHOUSE ENGINEER, v 16, May, 1956, pp 90-91.

Where previous electric couplings have been overhung from the diesel engine and driven gear, a new electric coupling for the U.S. Navy's LST vessels will be supported by its own bearings. Electric couplings are used to connect more than one diesel engine to pinions driving a common bull gear connected to a ship's propeller.

9. "Naval Gearing---War Experience and Present Developments," J. H. Joughin; I MECH E, v 164, 1951, pp 157-176.

Turbine blade failures resulting from vibration "scuffing" on trials and breaking of teeth at the roots, causing extensive damage requiring replacement of the gear-set, were experienced. Examination of these failures revealed shortcomings in manufacture and design which have now been largely remedied. It has been possible to establish standards of manufacture necessary to ensure reliability and to make economic use of available techniques and materials. Modifications to pinion helices and use of the full length of pinions are also discussed.

10. "Semiuniversal Toothed Couplings," E. Wildhaber; ASME TRANS, v 69, 1947, pp 925-930.

The semiuniversal toothed couplings (curvic type), when used with small shaft angularities, can transmit motion properly and carry a large load at small shaft angularities. They are simple, rugged, and inexpensive.

11. "Crank and Other Shafts Used in the Mercantile Marine," G. W. Manuel; INA, 1897.

A discussion of the causes of shaft failures in ships of the period.

HEAT EXCHANGERS

1. "Sponge-Rubber Balls Keep Condenser Tubes Clean," S. Elonka; POWER, v 104, n 3, March, 1960, p 230.

A unique feature is that tubes stay clean and never have to be cleaned chemically. They are serviced mechanically while the condenser is in full operation. This firm guarantees that tubes will maintain the same degree of cleanliness at all times. There is no stopping and starting of the

turbine for condenser cleaning, allowing more running hours per year for the turbine and longer turbine life. There are lower maintenance costs and easier handling because the equipment stays on the line.

2. "Some Factors Affecting the Performance of Condenser and Heat Exchanger Tubes," P. T. Gilbert; CHEMISTRY AND INDUSTRY (London), n 28, July 11, 1959, pp 888-895.

   The paper is divided into two parts, dealing first with the performance of tubes from the point of view of corrosion, and then with performance in the sense of the efficiency with which the condenser or heat exchanger performs its function. These two aspects are closely related. It is frequently found that when the efficiency is high the life of the tube is long, while poor operational performance is often accompanied by premature tube failures.

3. "Four Experimental Resin Coated Condensers," F. A Kaehler; GAT-T-544 (Goodyear Atomic Corp.), October 10, 1958. Available from OTS and Depository libraries.

   Four condensers were coated with epoxy resins; indications are that resin-coated tubes show less fouling than uncoated tubes. It is assumed that these condensers will last several years at a minimum. Coated condensers do not tend to accumulate silt and other debris as fast as the original condensers and, over a long period of time, will have a better heat transfer coefficient.

4. "To Clean Your Condenser---Backwash Is Cheapest!," T. E. Hitzman and H. W. Feist; POWER ENGRN, v 62, n 7, July, 1958, pp 72-74.

   Reversal of the circulating water through the condenser tubes provides the cleaning action by washing the debris from the tube ends and out of the waterbox while the condenser is operating at or near normal steam load. The savings gained in the reduction of downtime, plus the flexibility of application, warrants serious consideration of backwash systems.

5. "Spherical-Head Feedwater Heater," A. E. Pickford; POWER, v 102, n 3, March, 1958, p 103.

   The new spherical-waterbox, all-welded heater is designed to avoid leakage and high maintenance. The spherical waterbox, integral with tube sheet and heater shell, has ample room for a workman inside. Avoiding use of flanges and bolted joints eliminates potential leakage. The spherical

shape can best withstand thermal-shock stresses from quick start-ups and sudden outages.

6. "High Vacuum Distillation of Sea Water," BRIT MOTORSHIP, v 38, March, 1958, p 580.

High vacuum distillation of sea water with the Nirex plant using diesel-engine cooling water as a heat source is discussed. Vacuum maintenance ensures a boiling temperature below 104° F. Sea water passes with a high velocity and only a small part of it evaporates, thus eliminating deposits on tubes (six months service result shows no trace of deposit).

7. "All-Welded Feed Heaters Reach 3600 psi," R. A. Beck; POWER, v 101, n 8, August, 1957, p 84.

The Linden generating station boasts high-pressure feedwater heaters fabricated completely by welding. This construction eliminates all bolted joints, reduces the possibility of leakage, and yet permits head removal and access to the tube bundle without replacing any parts. The all-welded design is in line with today's increasing emphasis on reduced maintenance for power station equipment.

8. "Protection of Heat Exchangers Against Corrosion," L. C. Ferris; BRIT CHEM ENGRS, v 2, n 3, March, 1957, pp 122-127.

Hidden forms of corrosion are discussed, such as graphitization, dezincification, and impingement attack. Also discussed were modes of protection, choice of paint, cathodic protection, zinc and zinc alloys, performance of galvanic anodes, resistivity of the electrolyte, applied current anodes, uses of graphite, and permissible voltage.

9. "A New Way to Simplify the Steam Power Plant," H. A. Kuljian; COMBUSTION, v 28, n 1, July, 1956, p 51.

In the "K" and "K-F" heaters, for closed and open systems respectively, emphasis has been placed on rugged design and simplicity of construction for low maintenance problems. In the type "K-F" feedwater heater, the valves and controls are of simple construction and require very little attention. The use of these heat exchangers will reduce piping systems.

10. "Joining Tubes to Tubesheets for Corrosive Radioactive Chemical Service," W. R. Smith; BRIT WELDING J, v 35, n 4, April, 1956,

pp 306-310.

The paper discusses joining tubes to tubesheets in heat exchangers where a corrosion medium exists on one side. The method employs welding with the inert-gas tungsten-arc process, rolling, or combinations.

11. "How to Lengthen Condenser-Tube Life," H. A. Todhunter; POWER, v 100, n 3, March, 1956, p 85.

The 70-30 cupro-nickel condenser tubes have shown by far the least pitting of any of the tubes tested. After about 30,000 hours of service, most of the pits were less than 0.005 inch deep for the Cu-Ni tubes with 0.4% to 0.6% iron.

12. "Feedwater Heaters---A User's Viewpoint," S. M. Arnow; ASME TRANS, v 78, 1956, pp 1201-1205.

The paper gives a discussion of trouble-free operation requirements. A provision for avoiding corrosive-gas accumulation is needed. Suitable material protection against direct impingement on tubes by steam and flashing drains is also required. Other suggestions are proper location of vents, more attention to the mechanical details, and careful study of failures in order to determine the causes and to provide the cures. Several heater-cycle arrangements are shown and some typical troubles and remedies treated.

13. "Scale Formation in Sea-Water Distilling Plants and Its Prevention," H. Hillier; I MECH E PROC, v 1B, 1952-1953, pp 295-322.

The scales found in sea-water evaporators are formed of calcium sulphate, calcium carbonate, and magnesium hydroxide. Calcium sulphate scale can be avoided by using a sufficiently diluted brine concentration to maintain the sulphate in solution. The calcium carbonate and magnesium hydroxide scales can be completely prevented if the appropriate quantity of hydrogen ions is supplied by the injection of hydrochloric or sulphuric acid or an acid salt such as sodium bisulphate.

14. "Design and Performance of an Extended Surface Gas Turbine Regenerator," Sven Holm and Ray Lyerly; ASME, paper n 51-A-106.

The paper describes a new type of extended surface heat exchanger developed for a gas turbine plant for a natural gas pipeline pumping station. The particular unit described is not as compact and light as it could be made because

primary consideration was given to material strength and service life. This involved relatively heavy sections for both primary and extended surfaces.

15. "Expanded Tube Joints in Feedwater Heaters and Heat Exchangers," S. S. Fisher and G. J. Brown; ASME, paper n 50-A-124.

The authors recommend the optimum degree of expanding predetermined by tests conducted in advance of actual rolling operations. Experience shows that each tube and tubesheet combination of different metals and tube sizes requires a definite degree of expanding to develop its optimum joint strength.

16. "Fouling of Marine-Type Heat Exchangers," H. E. Bethon; ASME TRANS, v 71, 1949, pp 855-869.

A description is given of the design and construction of marine-type heat exchangers (lub-oil and jacket-water coolers, steam condensers, steam-and-thermal-compression distilling plants, and fuel-oil heaters) in addition to various design and operating procedures which affect fouling characteristics. Various examples are given of fouling in condensers, fuel-oil heaters, and distilling plants and how to cure them.

17. "Chemical Cleaning of Heat-Exchange Equipment," C. M. Loucks and C. H. Groom; ASME TRANS, v 71, 1949, pp 831-838.

The lubricating-oil coolers on ships have a heavy grease-like material on the oil side, composed of hydrocarbons with some sulphur-containing organic matter. An emulsion, consisting of an organic solvent with an aqueous alkaline solvent, used at elevated temperatures and from two to four hours contact time is usually sufficient to clean the cooler.

LUBRICATION, BEARINGS, AND SEALS

1. "Silicones in Lubrication," D. R. Johnson and M. R. Porter; BRITISH POWER ENGINEERING, v 3, n 1, June, 1961, pp 46-50.

Some unusual physical properties are produced due to the molecular structure of silicones, making them particularly valuable as high-temperature lubricants. The thermal life calculated from laboratory data for diester, paraffinic mineral oil, and phenyl methyl silicone is given. At present, silicones can be used for a variety of

applications where high temperatures or wide variations in temperature are experienced and the loading is light.

2. "Split-Roller Crank Shaft Bearing," THE SHIPPING WORLD, v 142, May 18, 1960, p 468.

   The replacement of solid self-aligning roller type main bearings on a diesel engine by split-roller bearings is said to increase bearing life, as well as reduce weight and risk of running hot.

3. "Bearing Oil Ring Performance," D. C. Lemmon and E. R. Booser; ASME TRANS, SERIES D, J OF BASIC ENGINEERING, v 82, 1960, pp 327-334.

   A series of tests were made with rings ranging from 2 3/4 inches to 16½ inches in internal diameter and at journal speeds up to 4000 feet per minute. Correlation of the results provides a means of calculating ring speed for any journal speed, from which oil delivery can then be estimated.

4. "Cast Iron Tinning," SHIPBLDG AND SHIPG REC, v 92, October 16, 1959, pp 511-512.

   A method has been found and cast iron shells are now being specially treated before lining to remove all traces of graphite from the surface, thus permitting an effective tinning operation prior to lining with whitemetal.

5. "Hydrodynamic Lubrication and Its Implication for Journal Bearing Design," F. T. Barswell; ASNE, v 71, August, 1959, pp 509-510.

   For references only.

6. "A High Alkalinity Diesel Cylinder Oil," MAR ENGR AND NAV ARCH, v 82, January, 1959, pp 13-14.

   High-alkalinity Caltex Super DCL oil is discussed; operating experience substantiates the claim that it reduces cylinder liner wear in diesel engines burning residual fuels. When compared with engines lubricated with straight mineral cylinder oil, engines lubricated with DCL show substantial wear reduction.

7. "Lubricating Oils and Greases in the Soviet Union," N. Cheremeteff; ERDL-1525-TR (PB 151,294), a literature research study of the

Army Engineer Research and Development Laboratory (Fort Belvoir, Virginia), May 22, 1958, 109 pp. Available from OTS.

This report is a comprehensive study of Soviet literature on lubricating oil. It has three chapters: I. Lubricants, II. Silicones and Oil Additives, III. Greases. Emphasis is placed on oil additives used to counteract wear, oxidation, mechanical deposits, instability, poor viscosity, and results of temperature variations. The different kinds of additives are defined, and their characteristics and functions are given.

8. "Improved Lithium-Based Multi-Purpose Greases," SHIPBLDR AND MAR ENG BLDR, v 64, October, 1957, p 603.

Lithium 12-hydroxy stearate soap in a grease gives outstanding properties which include mechanical and high temperature stability, high melting point, excellent resistance to water, long "shell life," and resistance to drying out and hardening in service. Such qualities enable these greases to be used for marine lubrication applications.

9. "The Torque and Wear Characteristics of Water-Lubricated Ball Bearings," W. H. Goldthwaite, D. W. Knoll, C. M. Allen; BMI-1216 (Battelle Memorial Institute), August 22, 1957, 43 pp. Available from Battelle Memorial Institute (Columbus, Ohio) and Depository libraries.

A program is described which evaluates the torque and wear characteristics of water-lubricated ball bearings as a function of ball-to-race conformity, contact angle, degree of alignment, and contact stress. Size 209 ball bearings with Stellite 19 races, Stellite 3 balls, and 17-4 pH stainless steel retainers were tested.

10. "How to Combat Corrosion from High-Sulphur Residual Fuel Oils," J. L. Philips and C. A. Weisel; MAR ENGR, v 62, n 6, June, 1957, pp 93-, 160, 168.

Piston-ring life doubled using the DX-130 Tro-Mar lubricant. The paper also discusses reducing crankcase corrosion action in journal bearings by treatment with trisodium phosphate.

11. "Selected Bibliography on Precision Instrument and Fluid Bearings with Annotations," J. G. Weir; materials report no. 48, PB-131791 (Naval Avionics Facility), March 14, 1957, 104 pp. Available from OTS.

The bibliography is intended to include all material pertinent to precision instrument ball bearings and fluid bearings. The references are divided into eleven categories: bibliography, design and selection, failures and causes, fluid bearings, jewel bearings, lubrication and lubricants, maintenance, manufacturing methods, materials, packaging and preservatives, and testing and inspection. Author and corporate author indexes are given, along with 440 references to the published literature.

12. "Additives with a Purpose," LUBRICATION, v 43, n 3, March, 1957, pp 25-40.

    This article gives commonly used lubrication additives in a table. Type of additive or compounds used, reason for use, and the mechanism of action are presented.

13. "Design Study of a Hydrostatic Gas Bearing with Inherent Orifice Compensation," S. K. Grinnell and H. H. Richardson; ASME TRANS, v 79, 1957, pp 11-12.

    A hydrostatic gas bearing can provide shaft support with very low friction in high-speed devices like centrifuges and gyroscopes and in precision static devices such as dynamometers. The friction torque required to rotate a hydrostatic bearing is from 100 to 10,000 times less than the friction torque required to rotate oil ball bearings. This paper presents information directly applicable to designs with optimum performance characteristics for hydrostatic gas bearings.

14. "Reticular Aluminum Tin for Bearings," GAS AND OIL POWER, Annual Technical Review Number, v 52, 1957, p 326.

    When metal-to-metal contact occurs between shaft and bearing with this reticular structure, there is an immediate supply of tin, which provides a thin soft layer of tin over the aluminum and prevents surface breakdown. It needs no lead-based overlay plating to keep shaft wear in check.

15. "A Study of the Effect of Wear Particles and Adhesive Wear at High Contact Pressure," B. E. Sciulli; ASLE, paper n 57-LC-2.

    Wear rate and friction data were collected both in the presence and absence of wear particles. The effect of sliding-surface geometry in trapping wear particles was also studied. The results suggest that an exponential relationship exists between wear rate and stress for the materials of the test.

16. "A New Cylinder Lubricant," BRIT MOTORSHIP, v 37, December, 1956, p 370.

A new diesel engine cylinder lubricant, Tro-Mar DX-130, has been developed. With this lubricant, it is claimed that a notable reduction in cylinder liner wear has been achieved when operating on residual fuels. The wear reduction varies from 72% to 90%.

17. "Advantages of Aluminum Bearings," R. F. Schaefer and D. B. Wood; POWER, v 100, n 12, December, 1956, p 124.

In comparing the life of conventional two-alloy and three-alloy bearings with aluminum bearings, the latter are found to be superior. This longer life is especially beneficial at high speed or for heavy duty. It prolongs the interval between engine teardown and part replacement. Aluminum bearings are also free from scoring when they are properly engineered and installed.

18. "Mechanical Seals," S. Elonka; POWER, v 100, n 3, March, 1956, p 109.

Mechanical seals overcome many disadvantages including unstable leakage, rapid shaft or shaft-sleeve wear, and sealing-oil complications. Seal types, materials, finish, cooling systems, and selection are also discussed.

19. "Stepped Thrust Bearings," R. C. R. Johnston and C. F. Kettleborough; read at a meeting of I MECH E, February 10, 1956.

The results show that the stepped-pad bearing operates over most of the range of experiment with a greater film thickness than the Michel bearing. The stepped bearing may be made self-aligning by forming the steps on a spherical surface, or by supporting the bearing elastically. Stepped areas may be formed on the inside of a cylindrical journal by electroplating. This provides stability under high speeds and light loads or rigidity in such applications as grinder spindles.

20. "Bearings for Marine Geared Turbines," A. D. Newman; read at a meeting of NECIES, v 72, February 10, 1956, pp 205-228.

Lubricating oil pump failure damage on journal bearings can be reduced by using a safety strip of sintered material, covered by a layer of white metal, and extending over the full width of the bearing. The length/diameter ratio of the bearing should be between 1/3 and 2/3, load up to

400 psi, and peripheral speed 25-50 H/sec.

21. "Recent Developments in Lubricants for Use in Marine Equipment," U. W. David and L. F. Richards; read at a meeting of IESS, January 24, 1956, p 345.

This paper is a general discussion of steam turbine lubricants, gas turbine lubricants, internal combustion engine lubricants, lubricating greases, fire-resistant fluids, and design of lubricants.

22. "Fretting Wear in Mineral Oil," D. Godfrey; LUBRICATION ENGRN, v 12, n 1, 1956, pp 37-42.

The results with the sulphur-containing additives showed that greater chemical reactivity was desirable in the case of additives which lubricate by sulphide films. Phosphorous-containing additives mostly reduced fretting wear by generating reaction films on the surface. Extremely high percentages of diethyl hydrogen phosphate decrease the wear.

23. "Report on Antigalling Coatings and Lubricants for Titanium," E. L. White and P. D. Miller; BMI TML R-34 (Battelle Memorial Institute, Titanium Metallurgical Laboratory), 1956. Unclassified. Available from OTS.

A survey of methods of reducing the galling type of wear of titanium and its alloys indicated that bare titanium and its alloys cannot be satisfactorily lubricated. The most acceptable lubricants thus far tested are of the fluorocarbon type. However, satisfactory wear performance for many operations can be obtained by the use of coatings of various kinds of titanium surfaces plus suitable lubricants. The wear resistance of the metal can be improved by oxide, nitride, and carbide case hardening and coating.

24. "Radiation Resistant Greases," J. G. Carrol, R. O. Bolt, B. W. Hotten; ASLE, paper n 56-LC-5.

The paper reports tests which evaluated physical properties, bearing life, oxidation, low temperature torque, copper corrosion, and wear in the presence of radiation. Several experimental products that gave excellent results in standard tests before irradiation also showed superior radiation resistance.

25. "General Radiation Damage Problems for Lubricant and Bearing-Type Materials," V. P. Calkins and C. G. Collins; ASLE, paper n 56-LC-2.

The effects of radiation on covalent-type materials like the ordinary organic lubricants can be considered as the results of ordinary physicochemical reactions that are initiated by a somewhat extraordinary source of energy.

26. "Conference on Bearing Development for Water-Lubricated Application: Summary Outline of Talks," WAPD-CTA(RM)-341 (Westinghouse Electric Corp., Bettis Plant, Pittsburgh), October 18, 1955, 38 pp. Available from OTS and Depository libraries.

Bearing materials and design, with particular attention to the mechanism which raises and lowers the control rods in a water-moderated nuclear reactor, are discussed.

27. "Bearings, Lubrication, and Lubricants: A Digest of 1954-1958 Literature," MECH ENGRN, v 77, September, 1955, pp 189-301; v 78, August, 1956, pp 711-714; v 79, September, 1957, pp 850-852; v 80, September, 1958, pp 64-74; v 81, October, 1959, pp 64-74.

A discussion and bibliography is given on journal bearings and bearing materials, ball and roller bearings, bearing design, bearing failure, thrust bearings, gear lubrication, and properties of lubricants.

28. "How Does the Makeup Rate Affect Life Span of Your Turbine Oil," H. H. Zuidema; POWER, v 98, n 6, June, 1954, pp 108-109.

Annual turbine oil makeup runs between 7% and 12% of the total system capacity. To find how rates affect oil life, varying makeup rates were used in a lab stability test. The result revealed that a 6.7% weekly makeup is needed to double oil life in a lab test setup.

29. "Materials for Water-Lubricated Bearings," H. B. Nudelman and C. H. Sump; TID-5187 (Armour Research Foundation), April 22, 1954, 70 pp. Available from the Library of Congress.

The efforts to correlate the wear technology of water-lubricated bearings are reported. The use of carbon and fluorocarbons as bearing materials for operation in hot water is discussed. The development of teflon-impregnated metal bearings are also discussed for an operating range of 200° F to 500° F.

30. "Mechanical Aspect of Seizing in Metal Wear," H. Czyzewski; ASME TRANS, v 76, 1954, pp 381-385.

Alloys of the class called "self-lubricated" have a resistance to "accelerated mechanical abrasion" which it has not been possible to duplicate by external lubrication. Alloys in this class include gray cast iron (graphite lubricant), oil-impregnated powder-metal compositions (oil lubricant), and leaded copper-base and iron-base alloys (lead lubricant). This paper presents the mechanical aspect of seizing in metal wear which accounts in a qualitative manner for the observed phenomena in accelerated mechanical abrasion.

31. "A Literature Survey on Causes of Ball Bearing Failure in Commercial Applications," G. S. Galtz; WAPD-Re-V(A)-30 (Westinghouse Electric Corp., Atomic Power Division), August 7, 1953, 29 pp. Available from the Library of Congress.

The causes of ball bearing failure are discussed under conditions of failure under normal operating conditions, failures caused by abnormal operating conditons, failures caused by defective bearings, and functional failures.

32. "Present Problems and Future Trends in Lubrication," W. A. Zisman; INDUSTRIAL AND ENGINEERING CHEMISTRY, v 45, July, 1953, pp 1406-1414.

This report summarizes the principal problems in the field of lubrication and their relation to recent advances. The lubrication problems discussed include wear prevention and corrosive properties of additives, shear strength and durability of extreme pressure agents, synthetic oils and their improvement, the rust inhibition and work stability of greases, new gelling agents and their improvement, high temperature greases and bearings, and the approach toward lifetime lubrication in electric motors.

33. "Seals to Minimize Leakage at Higher Pressure," B. A. Niemeier; ASME TRANS, v 75, 1953, pp 369-379.

The best fixed-point seals are those of the radial unsupported area class. The grooved piston will leak less than a plain piston because of the aligning action provided by the fluid flowing in the groove.

34. "Bearings, Lubrication, and Lubricants: A Digest of 1950-1953 Literature," MECH ENGRN, v 73, November, 1951, pp 892-896; v 75, November, 1952, pp 885-891; v 75, October, 1953, pp 801-808; v 76, September, 1954, pp 739-747.

Journal bearings and bearing materials, ball and roller bearings, thrust bearings, automotive lubricants, metal

working lubrication, boundary lubrication, and properties of lubricants are reviewed. The paper gives 72 references.

35. "Centrifugally Cast Bronze-Back Bearings for Heavy-Duty Operation," L. M. Tichvinsky; ASME TRANS, v 73, 1951, pp 391-398.

This discussion concerns Navy "M" bronze (U.S. Navy 46B8, Federal QQ-B-691a, Composition 1). The tensile strength of this type of centrifugal casting is 17.7 percent above that of the sand casting. Only the centrifugal method of casting bronzes for bearing back produces a material possessing the required high physical properties.

36. "Dimethyl-Silicone-Polymer Fluids and Their Performance Characteristics in Unilaterally Loaded Journal Bearings," J. E. Brophy, R. O. Militz, W. A. Zisman; ASME TRANS, v 68, 1946, pp 355-360.

Copper-lead, bronze, babbitt, copper, aluminum (17S), and Alfin alloy are common bearing metals that have been found very promising for use in unilaterally loaded journal bearings lubricated with a silicone fluid. These were especially effective with chromium-plated high-carbon-steel journals. These nonferrous bearings have been successfully operated with load increments of as much as 5500 psi applied during cycling tests.

37. "Piston Lacquering---Its Causes and Cures," H. C. Mougey; SAE J, v 53, October, 1945, pp 582-587.

There is no longer a serious problem with varnish or lacquer formation in engines. It has been reduced or eliminated by employing heavy-duty oil or installing oil coolers.

38. "Properties and Performance of Plastic Bearing Materials," L. M. Tichvinsky; ASME TRANS, v 62, 1940, pp 461-467.

The article describes the bearing materials bonded with synthetic resin. Data are given on the laminated materials, including physical properties, as well as the results of various bearing performance tests. The wear properties were also investigated on a wear-testing machine.

39. "Improvements in Propeller Shaft Bearings," A. S. Younger; INA, 1902.

A good discussion is presented of early experiments with oil-lubricated stern bearings.

MARINE ENGINEERING

1. "Vessel Component Performance Since World War II," E. S. Shulters and F. H. VanRiper; SNAME TRANS, v 68, December, 1960, pp 475-509.

   The paper discusses some recent component failures in Maritime Administration designed ships. It also discusses corrective measures which were taken.

2. "Service Experience with the Marad Liberty Ship Modernization Program Involving Four Different Propulsion Systems," R. Y. Newell, Jr. and T. J. Chwirut; SNAME (Chesapeake Section), April 2, 1959.

   Operational and maintenance problems of four liberty ships converted for the purpose of promoting the development of new types of main propulsion machinery are given. The corrective measures taken for these problems are also discussed.

3. "Flash Evaporators for Merchant Ships," G. F. Lietner; MAR ENGRN/LOG, v 64, March, 1959, pp 68-70, 148-149.

   The advantages of flash type evaporators for marine use are that there are no flow meters on the feed brine, no brine-sampling valve, no chemical-feed treatment system, and no provisions for cold shocking the evaporator. For long life, the materials used are non-ferrous: evaporator shell (silicon bronze or copper-nickel 90-10), tubesheets (Naval brass or copper-nickel 90-10), tubes (aluminum brass or Cu-Ni-90-10), sea water piping (Cu-Ni-90-10 with bronze silver solder fittings).

4. "Technical Progress in Marine Engineering during 1958," SHIPBLDR AND MAR ENG BLDR, v 66, n 611, January, 1959, pp 21-28.

   A survey on steam propulsion is given with reference to nuclear power, gas turbines, steam turbines, boilers, and diesel engines.

5. "Progress at Pametrada, 1957," THE OIL ENGINE AND GAS TURBINE, v 26, n 300, mid-August, 1958, pp 160-162.

   Fuels containing ethyl silicate liquid additive were used for residual-fuel tests. Additional tests were conducted using kaolin, aerosil, and micronised mica waste. Aluminum-coated tube deposits contained only slight amounts of iron, indicating negligible penetration and corrosion effects.

6. "Fluid Drive for Shaft-Driven Generators," MAR ENGR AND NAV ARCH, v 80, August, 1957, p 306.

Instead of having a separate prime mover for auxiliary power in the arrangement described, auxiliary power is supplied by the main engine through chains and a fluid coupling driven from the shaft.

7. "Fresh Water Generator," THE SHIPPING WORLD, v 136, May 22, 1957, p 509.

The unit operates under vacuum and uses waste heat from the main engine cooling water system, distilling sea water at such low temperatures that there is no risk of serious scale formation.

8. "Combined Steam and Gas Generator Machinery," THE SHIPPING WORLD, v 136, April 10, 1957, pp 367-369.

The paper discusses a proposal for the propulsion of a large oil tanker by a combined free-piston gasifier, gas turbine, and steam turbine installation. Information is given on wear of diesel engine parts after 1000 hours of operation. The gas turbine itself requires virtually no maintenance. Maintenance and wear figures are given only for the gasifiers.

9. "Some Aspects of Application of Planned Maintenance to Marine Engineering," W. H. Falconer; I MAR E TRANS, v 69, n 2, February, 1957, pp 37-51; v 69, n 3, March, 1957, pp 103-104.

The paper discusses mainly how to plan maintenance and how to record and tabulate data on maintenance.

10. "Technical Progress in Marine Engineering during 1956," SHIPBLDR AND MAR ENG BLDR, v 64, n 585, January, 1957, pp 27-36.

Cavitation on diesel engine cylinder liners depends on vibration. In certain series of engines, the vibration is reduced by the use of a two-piece heavy wall liner or cam-ground piston. Internal combustion engine valves were protected by heating, fluxing, and dipping the valve head in commercially-pure molten aluminum. This increases the lifetime two to three times.

11. "Flash Evaporator for Distillation of Sea Water," R. L. Coit and Y. S. Touloukian; WESTINGHOUSE ENGINEER, v 17, n 2, 1957, pp 58-60.

Flash evaporators of the type discussed have several advantages. Initial cost is lower and maintenance cost and time reduced to a minimum. The use of oceanographic thermal gradients and solar energy to obtain potable water through flash evaporators is considered.

12. "Naval Propulsion Progression in the Last Ten Years," Vice Adm. F. T. Mason; lecture given at a meeting of NECIES, v 73, November 2, 1956, pp 37-62.

    Types of propulsion machinery and the related vessels, the improvements attained in ten years, and maintenance and reliability of machinery are discussed in general.

13. "American Distilling Plant," THE SHIPPING WORLD, v 135, August 22, 1956, pp 172-173.

    The main advantage of the Soloshell plant is that, being of the low pressure type, it does not require frequent cleaning.

14. "Rotary Magnetic Seals," THE SHIPPING WORLD, v 134, April 11, 1956, p 363.

    The J.C. Rotary Magnetic Seal Co., Ltd. has developed a mechanical seal of an entirely new type which dispenses completely with stuffing boxes and packing materials. Tests carried out over a two-year period were very favorable and showed little wear.

15. "Steam Operated Distilling Plant," C. B. Tuley; BUREAU OF SHIPS J, v 4, April, 1956, pp 23-24.

    A distilling plant is described which is claimed to simplify maintenance compared to the submerged tube type.

16. "The Aerothermopressor," A. H. Shapiro, K. R. Wadleigh, B. D. Gavril, A. A. Fowle; ASME TRANS, v 78, April, 1956, pp 617-653.

    The aerothermopressor is a duct within which atomized water evaporates into a high-speed stream of high temperature gas, thereby inducing a rise in the isontropic stagnation pressure of the gas stream. It is used as an auxiliary for improving the performance of a gas-turbine plant at the exhaust of the power turbine.

17. "Flash-Type Distiller," MAR ENGR, v 61, March, 1956, pp 49-50, 83.

To maintain this plant at peak efficiency, it is necessary to clean it only twice a year and only five to six manhours of labor are required. Operation is simple; once vacuum has been obtained and the pumps placed in operation, the plant is controlled by one valve.

18. "New Design for Steam Operated Distilling Unit," C. B. Tuley; BUREAU OF SHIPS J, v 4, December, 1955, pp 19-20.

    A 50,000 gallon/day distilling unit is described. Advantages of this flash-type evaporator are given as compared with the submerged tube type.

19. "Bled Steam Air Heaters," THE SHIPPING WORLD, v 133, October 12, 1955, p 361.

    The paper discusses some design features which tend to reduce maintenance. The designs are not unique.

20. "Review of Ship Vibration Problems," W. K. Wilson; MAR ENGR AND NAV ARCH, v 78, Pt I, July, 1955, pp 258-263; v 78, Pt II, August, 1955, pp 305-308; v 78, Pt III, October, 1955, pp 380-382; v 78, Pt IV, November, 1955, pp 427-431.

    Ship vibration problems are discussed in some detail. The discussion includes machinery and hull vibration causes and design corrections.

21. "Distilling Plant for Turbine Ships," MAR ENGR AND NAV ARCH, v 78, Annual Steam Number, 1955, p 506.

    An important advantage of this plant is the elimination of scale on the heating surfaces due to the low temperatures. Removal of coils at short intervals and their manual cleaning are no longer necessary.

22. "The Changing Pattern of Maintenance and Repair of the Machinery of the Fleet," J. E. Cooke; I MECH E PROC, v 169, 1955, pp 932-951.

    Methods of maintenance and repair are examined as employed in ships and dockyards during World War I, the interval between the wars, World War II, and the period until the present day. The developments and changes in main and auxiliary machinery during these periods, their influence on methods of maintenance and repair, and the actions taken to meet the changes are each discussed in the period concerned. The more recent lessons of war are studied in relation to maintenance and repair, the increasing maintenance

load, and the advances in processes, equipment, and techniques which aid maintenance.

23. "Marine Engineering in the Royal Navy: A Review of Progress during the Last Twenty-Five Years," J. Kingcome; I MECH E PROC, v 160, 1949, pp 173-184.

This paper presents a study of design requirements, steam machinery, internal combustion engines, and gas turbines between 1923 and 1948. An improved turbine-gland system developed to combat war shock damage resulted in better machinery space conditions.

24. "Fifty Years of Marine Engineering," A. L. Mellanby; I MECH E PROC, v 143, 1940, pp 328-348.

Developments in marine engineering for the last fifty years are given. Reciprocating weight reduction, reduction gear proposals, condensers, steam turbines and their troubles, boilers, and diesel engines are discussed.

25. "The Propulsion of Ships by Modern Steam Machinery," J. Johnson; INA, 1929.

Problems of condenser tube failure and also those of Scotch and water tube boilers are discussed. Efficiencies for various types of machinery are indicated. A good picture of marine engineering in 1930 is given.

26. "Steam Pipes," J. T. Milton; INA, 1899.

Early steam pipe failures are discussed, and a tabulation of principal failures from 1885-1898 is given.

27. "Some Details in Marine Engineering," T. Mudd; INA, 1891.

The paper discusses design details and points of difficulty which apply to marine boilers, stern tube boring, machining, crankshafts, piston packing, and cylinders. It is a good presentation of current engineering problems of the period.

28. "Copper Steam Pipes for Modern High Pressure Engines," W. Parker; INA, 1889.

The failure of copper steam pipes on two ships is discussed. Failure is considered to be caused by brazing. Tests made on copper pipe are also discussed.

29. "On Steam-Ship Machinery Repairs," A. K. Hamilton; INA, 1884.

This is a general treatment of types and causes of machinery failures and the cost for maintenance of three ships.

30. "On the Strength of Crank Shafts," J. T. Milton; INA, 1881.

This is a sequel to the 1879 paper. The effect of length of stroke on engines with misaligned bearings is discussed.

31. "On Some Causes of Failure of Crank Shafts in Marine Engines," INA, 1879.

The paper handles possible reasons for the failure of steam engine crankshafts. It considers especially the effects of bearing misalignment.

32. "Further Experiences in Marine Engineering," R. Murray; INA, 1867.

The problems of early surface condensers are discussed.

33. "Some Recent Experiences in Marine Engineering," R. Murray; INA, 1865.

Problems of an untreated closed feed system with no blowdown and those of engine lubricants in the boilers are covered along with data on a low-pressure (20 psi), single-cylinder engine plant.

34. "Development of Device to Protect Turbo Generator from Damage Due to Thrust Bearing Failure," R. Bruce, C. A. Roberts, K. C. Byram; AIEE TRANS, v 77, Pt III, pp 1383-1386.

Failure of thrust bearings working at high temperatures and pressures is discussed, and a method of protecting the machine by automatic tripping on a predetermined increase in metal temperatures in given. Bearing metal temperature is detected, recorded, and used to actuate automatic tripping instruments to protect the turbine.

MATERIALS

1. "Some Factors in the Selection of Metals for Marine Engineering," D. Birchon; I MAR E, supplement to TRANS, v 73, n 3, March, 1961.

Required life, fatigue failure, stress corrosion, caustic

embrittlement, brittle failure, irradiation damage, creep deformation, and thermal shock are discussed. Suggested materials to prevent or decrease these failures are given with the 43 references.

2. "Increased Alloy Fatigue Strength," COMBUSTION, v 16, August, 1960, p 32.

   Coatings of certain polar organic compounds on specimens of steel, magnesium, and copper-beryllium alloys markedly increase fatigue strength according to experiments carried out by the U.S. Bureau of Standards.

3. "Stress Corrosion Screening Tests of Materials for Steam Generator Tubing in Nuclear Power Plants," D. E. White and E. G. Johnson; CORROSION, v 16, n 7, July, 1960, pp 92-96.

   The experiments described evaluate different materials for use in steam generator tubing containing high pH boiler water.

4. "Sprayed Metal Coatings for Abrasion, Corrosion, and Oxidation Resistance," G. R. Bell; BRIT WELDING J, v 7, May, 1960, pp 305-311.

   Apart from high abrasion resistance, the sprayed and fused coatings have extremely good corrosion resistance in many chemical conditions, as well as very good oxidation resistance. The results of corrosion tests for a Ni-Cr-B-Si alloy are summarized in the paper.

5. "Plastic Refractory Furnace Linings," MAR ENGR AND NAV ARCH, v 83, n 1007, May, 1960, p 228.

   The use of a plastic refractory enables a complete monolithic structure to be obtained, thus eliminating the joints where brickwork failure tends to start. Plastics are highly resistant to spalling, which is often the result of continuous operation at high ratings on poor fuel. For high duty use with temperatures about 1400° C, the Super Mono-Fibrik grade is recommended.

6. "Qualification of Inconel for Nuclear Power Plant Applications," H. R. Copson and W. E. Berry; CORROSION, v 16, n 2, February, 1960, pp 123-129.

   The study establishes that Inconel is an excellent construction material for primary and secondary waters of pressurized water reactors.

7. "Motor Insulation Is Better Than Ever: New Materials and Methods Pave the Way," N. Peach; POWER, v 104, February, 1960, p 61.

Classification and properties of wire insulation, ground insulation, coil insulation, and form-wound insulation are discussed.

8. "Growth and Scaling of Cast Iron," I. C. Huges; BCIRA J, v 8, n 1, 1960, pp 7-28.

An explanation of the mechanism of growth and scaling is given, and the conditions which promote them are described. Growth at low temperatures can be retarded by quite small amounts of alloying elements (chromium, copper, antimony, tin), which delay or prevent the graphitization of pearlite. Growth at elevated temperatures is decreased by reducing graphite flake size.

9. "Creep Tests on a Flake Graphite Cast Iron at 400° C," K. B. Palmer; BCIRA J, v 7, October, 1959, pp 839-842.

232° C is the present limiting temperature for the use of cast irons in steam engineering in this country. It is felt that this limit could be safely raised to 343° C as recently reported tests on 35 cast irons have shown no appreciable growth due to oxidation or pearlite decomposition at temperatures up to 400° C.

10. "Metal Diffusion Chromizing Process," ENGRS DIGEST, v 20, August, 1959, pp 341-342.

By employing combined chromium/aluminum diffusion, effective resistance to corrosion at temperatures up to 1305° C can be obtained. When sulphur-bearing gases are present, adequate resistance to corrosion can be obtained by chromizing, followed by superficial high-temperature oxidation of the surface to chromic oxide. Another advantage of the higher percentage of surface chromium provided by the process is that it permits fuller use to be made in a wide range of applications of the physical properties of chromium itself (extreme hardness, resistance to abrasion, and virtual immunity to oxidation or attack by many chemicals). This advantage is combined with the ability to maintain these properties over a wide temperature range.

11. "Effect of Shot Peening," S. Takeuchi and T. Homma; ENGRS DIGEST, v 20, June, 1959, pp 245-246.

The fatigue limit at 10^7 cycles of the polished brass

specimen was 18.0 kg/mm^2, compared with 20.4 kg/mm^2 for the shot-peened specimen, representing an increase of about 13%. The fatigue limit at 10^7 cycles of the decarburized specimen was only 31 kg/mm^2, whereas the corresponding value for the shot-peened decarburized specimen was 48 kg/mm^2. This represents an increase of as much as 54%. Increased intensity of shot-peening has a beneficial influence on the fatigue strength of decarburized specimens, even to the point of causing it to rise to approximately the same value as that of polished specimens.

12. "Glass Ceramics," SAE J, v 67, June, 1959, p 99.

Pyroceram, a new glass-ceramic material, has properties that suggest its use for bearings, spacer and seal rings, piston tops, and valves. Stronger than glass and higher in surface hardness, it has high electrical resistance and can be finished to precise tolerances. Because of the low thermal expansion coefficient, it withstood temperatures as high as 1800° F and as low as -200° F. It can function with or without a lubricant with little wear or increase in friction coefficient, and it can operate in corrosive liquids with less deterioration than a metal bearing.

13. "M-252 Alloy for Heavy Duty Gas Turbine Buckets," G. R. Fusner and D. L. Newhouse; ASME TRANS, SERIES A, J OF ENGINEERING FOR POWER, v 81, n 2, April, 1959, pp 161-176.

The results of tests indicate that M-252 (nickel base alloy) has a corrosion rate which is three or four times greater than S-816 material. The application of M-252 is limited to gas turbines which burn gaseous fuels (limit temperature of 1400° F).

14. "Thermal and Elastic Properties of Cast Irons," D. Fitzgeorge and J. A. Pope; read at a meeting of NECIES, v 75, March 23, 1959, p 285.

The main conclusions drawn from the tests and previous work are: Sound steel casting are more suitable material for combustion-chamber parts than any of the cast irons; Spheroidal-graphite type cast iron possesses longer service life under thermal straining conditions than any of the flake-graphite cast irons. A suggested order of merit of materials subjected to thermal straining is: 1) steel casting, 2) spheroidal-graphite cast iron with ferrite matrix, 3) spheroidal-graphite cast iron with pearlite matrix, 4) flake cast iron with short, thick flakes of graphite and low, free graphite content,

5) flake cast iron with long, thin graphite flakes and high, free carbon content.

15. "Properties of Refractory Materials (Collected Data and References)," W. G. Bradshaw and C. O. Matthews; LMSD-2466 (Lockheed Aircraft Corp., Missile Systems Div., Sunnyvale, California), January 15, 1959, 114 pp.

A survey was made of the elevated-temperature characteristics of refractory materials melting above 2500° F. Data are presented on the melting points, ductility, and elevated-temperature stability of the refractory metals, carbides, nitrides, oxides, silicides, sulfides, beryllides, aluminides, other intermetallics, phosphates, and uranates. The thermal shock resistances, thermal conductivities, thermal expansions, and emissivities reported for these materials are given. The effect of nuclear radiation on ceramics is reported. The mechanical properties of refractory materials are briefly reviewed.

16. "Introduction to Fatigue in Marine Engineering," K. Batten; I MAR E TRANS, v 70, n 11, November, 1958, pp 331-355.

The fatigue failure and fretting corrosion related to this type failure are discussed. The characteristic features of basic types of fatigue cracks are given in the appendix. Crack detection methods for fatigue cracks are given along with proposals to prevent fretting corrosion. These proposals are surface treatment, fit and finish of the surfaces, and lubrication of the surfaces.

17. "Viton: Your New Design Material," S. Elonka; POWER, v 102, n 6, June, 1958, p 118.

A new synthetic rubber is discussed for service in oils, fuels, and solvents at over 400° F. It is a linear copolymer of vinylidene fluoride by weight. Properties of Viton are resistance to heat aging; resistance to fluids and chemicals; better hardness, tensile strength, and elongation than any elastomer; resistance to compression set; low-temperature properties which are not astounding but adequate; and resistance to ozone and weathering. Viton is used as valve-stem seals on truck engines, brake cups, front pump seals, gasoline pumps, thermostat bellows, fuel tanks, and portable storage tanks.

18. "'Chromallized' Steel," R. P. Seelig; SAE J, v 66, May, 1958, pp 42-44.

Diffusing chromium into the surface of metal results in resistance to corrosion and oxidation. The wear and abrasion resistance exhibited is similar to tungsten carbide surfaces. Used for gas turbine vanes and blades, it requires high hot strength as well as resistance to oxidation and erosion. Protection is provided against oxidation at temperatures close to 2000° F, along with increased life in metal-to-metal contact friction. It was used in pistons in a vertical pump, generating pressures up to 2000 psi, with reduced scoring and leakage; it was also used in steam traps.

19. "Materials for Superheater Tubes and Supports," D. W. Crancher; I MAR E TRANS, v 70, n 3, March, 1958, pp 77-94, 94-103 (discussion).

Superheater tube and support materials; creep; high temperature; fouling and corrosion problems as related to content of fuel oil; and means of failure prevention are discussed with numerous references.

20. "A New Look at Specialized Refractories as Maintenance Tools," R. W. Brown; ASME, paper n 58-A-187.

Ceramic-bonded silicon-carbide was applied to a flue connecting the gas generator and carburator (as liner) and showed no erosion after 10,000 hours. The use of silicon-carbide boiler tube facings was also discussed.

21. "Recent Metallurgical Problems in Marine Engineering," B. Todd; I MAR E TRANS, v 69, n 8, August, 1957, pp 320-325.

A general discussion of metallurgical problems and their causes is presented with emphasis on condenser tube and propeller shaft liner corrosion, use of spheroidal-graphite iron for ships' valves and diesel engine pistons, and development of simple alloys.

22. "Development and Uses of Spheroidal-Graphite Cast Iron for Marine Applications, with Special Reference to Diesel Engines," A. G. Arnold and B. Todd; BCIRA J, v 6, n 11, April, 1957, pp 588-599.

More exacting specifications for the materials used in diesel engine construction are required, due to the continued improvement of this engine in recent years. Improvements effected and experiences with the use of spheroidal-graphite irons for diesel pistons are fully described.

23. "Chrome Coat That Shaft Now," J. M. A. VanDerHorst; POWER, v 101, n 1, January, 1957, p 118.

> Chrome of 800 to 1000 Brinnell is electrodeposited on wearing surfaces; this gives almost wear-proof life. The thickness of the coating depends upon shaft size and service and ranges from 0.006 to 0.060 inch on the radius. About 0.001 to 0.002 inch more chrome must be added for finishing. A chrome-plated high-speed (over 750 rpm) internal combustion engine shaft has a better chance of surviving due to inherent resistance to wear and abrasion.

24. "Effect of Surface Finish on the Fatigue Strength of Titanium Alloys RC110B and Ti140A," G. M. Sinclair, H. T. Corten, T. J. Dolan; ASME TRANS, v 79, 1957, pp 89-96.

> Through the use of microhardness measuring techniques, it was found that the different finishing methods introduced varying degrees and varying departments of cold work in the surface layers of the metal. Cold rolling produced the highest hardness, which is greatest fatigue strength, while grinding gave the lowest value.

25. "Corrosion Bibliography on Cobalt and Cobalt Alloys," NP-6913 (Cobalt Information Center, Columbus, Ohio), 1957, 11 pp.

> Approximately 150 references, some annotated, are cited from periodicals and report literature.

26. "The Effect of Composition on the Oxidation Stability of Electrical Oils," J. L. Jazl; AIEE, paper n CP-57-84.

> A mineral oil in use must give satisfactory performance not only during initial service but also after extended operation. The authors discuss how the chemical composition of the oil affects its performance and, in particular, its oxidation stability.

27. "Non-Ferrous Metal Research," THE SHIPPING WORLD, v 135, July 4, 1956, p 19.

> The procurement of the report described in this article would be of some help in choosing materials for condenser tubes, gas turbines, etc., in that it reviews research done in these areas in 1955.

28. "**Flame** Plating with Tungsten Carbide," R. H. Eshelman; ENGRS DIGEST, v 17, March, 1956, pp 99-100.

Tungsten carbide plating has excellent resistance to thermal shock. Strips loaded in tension to 15,000 psi, heated to 1350° F in 45 seconds, and cooled to 120° F in 30 seconds showed good test results.

29. "New Piston Ring Material," ENGRS DIGEST, v 17, March, 1956, pp 85-86.

It has been established that an aluminum-alloy piston with a cast-in austenitic ring carrier reduces the rate of wear on both the piston and the cylinder liner under corrosive conditions. After heat treatment and tempering, these rings are highly resistant to wear and to corrosion attack from fuel oils of high sulphur content.

30. "Ferrous Materials in Marine Engineering," S. F. Dorey; read before NECIES, October 28, 1955, pp 27-45.

The use of ferrous materials in marine engineering for shafting, crankshafts, rotorshafts for steam and gas turbines, reduction gearing, pistons, turbine blading, stationary turbine parts, and steam plant is discussed. Their service in sea water is also treated.

31. "Dielectric Breakdown Properties of Thermosetting Laminates," N. A. Skow; ASME TRANS, v 77, 1955, pp 701-704.

Thermosetting laminated plastics are excellent electrical insulators; these materials are also mechanically strong, light in weight, and easy to fabricate. They resist chemical corrosion, moisture, aging, heat, and temperature deterioration. To establish safe operating loads, tests for the endurance limits of dielectric strength were run on each of several grades of thermosetting plastic laminates, plotting voltages against time. The data thus obtained indicate that, for a given thickness and atmospheric condition, a maximum voltage exists below which failure will not occur.

32. "Nodular Cast Iron---Its Present Position and Future Prospects as an Engineering Material, with Special Reference to Its Suitability for Crankshafts," S. B. Bailey; I MECH E PROC, v 168, 1954, pp 643-653.

The particular application of nodular cast iron to crankshafts is discussed in detail. It can replace alloy flake-graphite irons with a gain in ductility and impact resistance. It is already replacing graphitic cast steel, chiefly because of its better founding properties and because its lower

pouring-temperature facilitates the use of mass-produced shell moulds.

33. "Some 12 Percent Alloys for 1000-F to 1200-F Operation," D. L. Newhouse, B. R. Seguin, E. M. Lape; ASME, paper n 53-A-168.

The paper considers alloys which include some martensic 12% Cr types. Detailed high-temperature creep-relaxation and stress-rupture data are given for 12% Cr(Type 403) and for six alloy modifications including 12% Cr-Co-W-V, 12% Cr-Mo-V, 12% Cr-W-V, 12% Cr-Mo-W-V, 12% Cr-Cb, and 12% Cr-Ni-W. These materials prove their importance in steam and gas turbine buckets, compressor blading, bolting, valve stems, and similar applications.

34. "The Influence of Aluminum and of Various Heat Treatments on the Creep Properties of Low Carbon Steel Superheater Tubes," D. C. Herbert and E. A. Jenkinson; NECIES, v 69, 1952-1953, pp 27-44.

A steel having an addition of 1 lb. of aluminum per ton provided tubes having satisfactory creep properties in all conditions of fabrication and heat treatment.

35. "Alloys and Design Fight Condenser Ills," W. Lynes; POWER, v 95, n 3, March, 1951, p 122.

A discussion is presented of improvements in materials, design, and operation to meet problems of water, steam, and air flow.

NUCLEAR REACTORS

1. "Reactor Safety," R. J. Smith; TID-3525, Rev. 2 (Office of Technical Information Extension), September, 1960. Available from OTS and Depository libraries.

References to 411 unclassified AEC research and development reports and 151 unclassified non-AEC reports are presented. Reactor safety, materials, and operation to provide maximum safety are included.

2. "Informal Listing of Bibliographies of Atomic Energy Literature," TID-3700 (Suppl. 5 to TID-3043, Rev. 1, Suppl. 1), June-July, 1960. Available free from Office of Technical Information Extension.

Bibliographies issued or in preparation on marine reactors

and safety are given.

3. "The Safety of Nuclear Powered Merchant Ships," J Neumann; NUCLEAR ENGRN, n 5, April, 1960, pp 169-171.

   Rules for design and construction of nuclear powered merchant ships proposed by the Ministry of Transport (Great Britain) are interpreted with special reference to the location of propulsion turbines and containment structure.

4. "OMRE Operating History and Experience," K. H. Campbell; NUCLEAR ENGRN, v 5, n 45, February, 1960, pp 53-57.

   A review of experience gained in 1500 Mwd operation between February and August, 1958, covers coolant decomposition, fuel elements, heat transfer surfaces, corrosion, coolant activation, and component dependability and maintenance. Inspection of the internal components of the pumps failed to disclose any evidence of erosion or corrosion after more than two years of essentially continuous operation, and only normal wear has occurred on bearings and rotating seal surfaces. Packed valves have been completely satisfactory. Standard raised-face flanges are being employed on the coolant and gaseous systems, and flange leakage has not been a problem. Due to the low radiation levels prevalent even during operation, maintenance of components has not been a problem either.

5. "1000 KW(e) Portable Boiling Water Nuclear Power Plant," TID-5742 (Combustion Engineering, Inc., Nuclear Div.), 1960. Available from OTS and Depository libraries.

   Proven standard commercial components are used to ensure a high degree of reliability at reasonable cost. Minimum downtime and simplicity of operation are achieved with the natural circulation water cycle. The reactor requires refueling only once every four years.

6. "Bibliographies of Interest to the Atomic Energy Program," H. E. Voress, J. M. Jacobs, N. K. Smelcer; TID-3043, Rev. 1, Suppl. 1 (Technical Information Service Extension, AEC), November, 1959. Available from OTS and Depository libraries.

   561 references to bibliographies and literature surveys are provided with report numbers and availability indexes.

7. "Reactor Safety," R. J. Smith; TID-3525, Rev. 1 (Technical

Information Service Extension, AEC), November, 1959, 39 pp. Available from OTS and Depository libraries.

A title list of 269 unclassified references to AEC and non-AEC reports is given that supplements "Reactor Safety, A Selective Bibliography" (TID-3073). These references are presented on reactor systems, materials, and operation designed to provide maximum safety for the reactor, reactor personnel, and environs. Information is included concerning incidents and conditions of operation considered hazardous.

8. "Pressurized Water Reactors (A Literature Search)," S. F. Lanier; TID-3530 (Technical Information Service Extension, AEC), June, 1959, 32 pp. Available from OTS and Depository libraries.

   References are given on the Shippingport Pressurized Water Reactor, Army Package Power Reactor, Indian Point Reactor, N.S. SAVANNAH, and general reports on pressurized water reactors.

9. "Operating Experience with Vallecites Boiling Water Reactor," L. Kornblith, Jr. and W. A. Raymond; ELEC ENGRN, v 78, n 4, April, 1959, pp 334-338.

   Maintenance work on the reactor has proved to be simple. In four months, the reactor has been opened 13 times to install, remove, or rearrange fuel as part of the experimental program. In one of these instances, the work required less than 24 hours. Methods of operating and staffing are also discussed.

10. "Homogeneous Reactor Project Quarterly Progress Report for Periods Ending April 30 and July 31, 1958," ORNL-2561, (Oak Ridge National Laboratory), February 4, 1959, 361 pp. Available from OTS and Depository libraries.

    This progress report on the homogeneous reactor discusses the engineering of pumps, pipes, and valves. It also discusses many other things of no direct interest to this project.

11. "Heat Exchanger Design for Heavy Water Reactor Service," A. D. Duff, Jr. and E. E. Wilson; CAN J CHEM ENGRN, v 36, n 5, October, 1958, pp 203-206.

    This is a design for heavy water exchangers in primary coolant loops of a nuclear power plant to meet requirements for low holdup, minimum leakage, minimum maintenance, ease of maintenance, and minimum fabrication cost.

12. "Bibliography for Nuclear and Conventional Merchant Ships," F. L. May; ASAE-S-10 (American Standard, Atomic Energy Div.), June 30, 1958, 105 pp. Available from OTS and Depository libraries.

This listing is compiled from references used by numerous organizations in studies pertaining to various phases of the application of nuclear power to merchant ship propulsion. The arranged references contain the subjects of propulsion machinery and auxiliary equipment, reactor types, and basic information on reactor design.

13. "A Guide to the Selection of Canned Motor Pumps," W. W. Wepfer; presented at NESC (Chicago), preprint 77, Session II, March 17-21, 1958.

Typical design and performance parameters are shown for a wide range of sizes of canned-motor pumps. All units are for pressurized water systems operating in the range of 2500 psi pressure and 500° F temperature. Motor life of 15 to 20 years under light radiation is possible. Twenty of the questions most frequently asked by prospective users are discussed and answered.

14. "Main Coolant Instrumentation for High Performance Pressurized Water Reactor Power Plants," L. C. Moyes; AIEE TRANS, v 77, Pt I (Communication and Electronics), 1958, pp 683-690.

This instrumentation provides a high degree of reliability and long life under severe environmental conditons through the use of a magnetic amplifier and silicon rectifiers.

15. "Nuclear Steam Plant for Waterless Zones," W. R. Wootton; AUSTRALIAN ATOMIC ENERGY SYMPOSIUM, 1958, pp 448-454.

The design of a steam plant to minimize gland leakage and other water losses is discussed. This plant uses an air-cooled condenser and relatively high back pressure. The design envisages an ambient air temperature of 100° F and uses a simple design of a hermetic, air-cooled condenser and a current design of a gas-cooled, graphite-moderated reactor.

16. "Some Problems in Application of Nuclear Propulsion to Naval Vessels," H. G. Rickover, J. M. Dunford, T. Trockwell, III, W. C. Barnes, M. Shaw; SNAME, paper n 12, November 14-15, 1957 20 pp.

Steam pressures at full load ranging from 200 to 600 psia

are used in naval reactor plants; this pressure is low in comparison with those of modern conventional steam plants. One reactor per shaft gives lower machinery weights and shield weights than two reactors per shaft for the same total horsepower. Reactor cores have had their life extended considerably, and fabrication methods are being simplified. Reactor control equipment, which can operate without any electron tubes, is also discussed.

17. "Fluid-Fuel Reactors for Nuclear Merchant Ships," C. B. Ellis; **SNAME**, paper n 11, November 14-15, 1957.

A power reactor requires no control rods of any type. Saturated-steam turbines could be used without requiring much alteration in the nuclear reactor system. The reactor operator's only job is to observe the fuel-output temperature and to ascertain that the pumps are running properly. No expensive dissolving, purifying, and refabricating of radioactive-fuel assemblies are needed. Uranium refueling is necessary only once a year and requires only 24 hours.

18. "Bibliography on Maintenance, Maintenance Equipment and Closures," B. D. Draper; CF-57-11-44 (Oak Ridge National Laboratory), November 4, 1957, 6 pp. Available from OTS and Depository libraries.

This is a useful reference paper for the maintenance of nuclear reactors, although some of the references are secret and classified.

19. "Reactor Safety Bibliography---Selected Unclassified References," AECU-3589 (Division of Reactor Development, Engineering Development Branch, AEC), October 31, 1957, 18 pp. Available from the Library of Congress.

This bibliography contains 42 references of general interest, 19 references about metal-water reactions, 12 references about fission produced release, 35 references about containment, 38 references about transient tests and analysis, 19 references about Hazards Summary reports, and 11 references about fast reactor safety.

20. "Piping Installation for Burst-Cartridge Detection Gear in Calder Hall Reactors," J. M. Laithwaite; BRIT WELDING J, v 4, n 8, August, 1957, pp 360-367.

This paper covers the installation of 17/32 inch outside diameter stainless steel pipes into the reactor for a detection system so that all joints and fastenings would

last for the full life of the plant without any maintenance whatever.

21. "Valves for Atomic Power Open New Foundry Market," J. J. Kanter; FOUNDRY, v 85, n 7, July, 1957, pp 130, 133, 136.

In this paper, quality requirement problems of primary loop-valves (which control flow of primary fluid), valve-stem sealing against leakage, different corrosion problems in each type of reactor primary loop piping, causes of failure, requirements for valve part surfaces, and heat treatment are discussed.

22. "Maintenance of Various Reactor Types," B. D. Draper; CF-57-4-92 (Oak Ridge National Laboratory), April 8, 1957, 26 pp. Available from the Library of Congress.

A list is given of reactor power plant types, arranged in order of increasing difficulty of maintenance with the advantages and disadvantages maintenance-wise of each. The types of plants listed are gas cooled, pressurized water, boiling water, sodium graphite, fast reactor, aqueous homogeneous, fused salt homogeneous, and liquid metal fuel.

23. "Design and Development of the Coolant System for the Sodium Reactor Experiment," D. T. Eggen, A. M. Stelle, M. Meisler; NESC, paper n 57-115.

The development of the technology associated with the sodium-cooled, graphite-moderated type of reactor is discussed. Components have been designed, developed, and tested. They include pumps, valves, cold traps, venting systems, and coolant instrumentation. The results of this engineering and development work are described in detail for the heat transfer system. Stress and heat transfer data and experimental results are also discussed.

24. "Some Operational Problems of the Nuclear Power Plant," A. R. Jones; NESC, paper n 57-24.

The authors discuss problems of start-up, normal operation, shutdown, maintenance, refueling, and manpower.

25. "Operational Experience with the Borax Power Plant," W. H. Zinn et al; NUCLEAR SCIENCE AND ENGINEERING, v 1, n 5, October, 1956, pp 420-437.

The operation of the Borax-III for 1170 hours at 300 psig is discussed. Since a high concentration of oxygen in steam causes extensive corrosion to turbine and condenser materials, hydrogen gas was added to the reactor water. The oxygen content of the steam was markedly reduced. Monitoring the activity of the gases from the condenser air ejector may prove to be a reliable means of early detection of breaks in the fuel cladding material.

26. "Nuclear Propulsion Plant," THE SHIPPING WORLD, v 135, September 26, 1956, pp 275-278.

The use of an inert gas, such as nitrogen, as the working medium in this plant eliminates the problem of chemical attack on the reactor as well as the turbine.

27. "Some Problems in Maintenance of Nuclear Reactors," H. G. Davey; I CHEM E TRANS, v 34, n 3, 1956, pp 204-218, 219-222 (discussion).

Reactors of the graphite-moderated and air-cooled type are discussed. Maintenance work which had to be done under reactor conditions because of the effects of flux, temperature, and air flow developed faults. Examples of work which has been done and the techniques evolved are given along with their effect on design of future reactors.

28. "Carbon Steel Promises Cheaper Reactor Systems," R. U. Blaser and J. J. Owens; NUCLEONICS, v 14, n 1, 1956, p 68.

The Babcock and Wilcox Co. has carried out an investigation into the rates of corrosion of carbon steel in water at various temperatures and rates of flow in order to find out whether this material might safely be used in nuclear reactors as a substitute for stainless steel.

29. "Bibliography on Nuclear Propulsion for Ships," B. Yates; revision of IGRL-IB/R-24 (United Kingdom Atomic Energy Authority). Available from Depository libraries and British Information Service, 45 Rockefeller Plaza, N. Y.

A bibliography containing 1158 references is presented on operation, performance, and the safety of various reactors for ship propulsion.

PIPING

1. "New Design of Steam Valve," SHIPBLDR AND MAR ENG BLDR, v 67,

January, 1960, p 51.

The new design incorporates a unique flexible titanium alloy disc which is resistant to corrosion and erosion. Seat galling and corrosion and the destructive wire-drawing effect of steam are eliminated by the special design of the preseator valve. It is suitable for use with steam at a pressure of 200 psi and a temperature of 500° F.

2. "Flexible Piping for Marine Auxiliary Systems," MAR ENGR AND NAV ARCH, v 82, n 998, September, 1959, p 361.

It is claimed that the flexible piping described in this paper has the advantages of inherent flexibility, hence vibration-absorbing properties as well as abrasion and wear-resistance, coupled with freedom from electrolytic action, marine deposits, and the effect of oil-soaking.

3. "Now, This Missile Coupling Is Ready to Seal Your h-t, h-p Joints," S. Elonka; POWER, v 103, n 2, February, 1959, p 192.

The coupling compensates for temperature because the hotter it gets, the harder it grips the pipe flange and, therefore, the tighter it seals. The design is simple and light weight; it can be connected and disconnected in a few minutes. At present, it handles 8000 psi in 3/4 inch diameter pipe sizes, down to 70 psi in 20 inch diameters. Corrosion resistance of the coupling and great strength come from an embossed, age-hardened Inconel "X" sectional shell or band that makes up the body of the coupling.

4. "Graphitization in the Power Station at the Oak Ridge Gaseous Diffusion Plant," C. H. Mahoney and W. S. Dritt; K-1404 (Oak Ridge Gaseous Diffusion Plant, Tenn.), November 6, 1958, 40 pp. Available from OTS and Depository libraries.

A review is presented of the progress of graphitization, and of the rehabilitation measures taken to control it, in the carbon-½% molybdenum steel components of the power station at the Oak Ridge Gaseous Diffusion Plant. Molybdenum contents of 0.7% to 1.0%, however, do appear to minimize the influence of abnormality. Samples taken in 1957 from two valves that had been normalized in 1952 were found to be graphite free.

5. "Valve and Piping Hookups: Key to Tight Seating Steam Shutoff Valves," M. Stein; POWER, v 102, n 9, September, 1958, p 106.

Small amounts of condensate will accumulate on closing

surfaces of valves; any air in the system brings oxygen in contact with this water to produce an active cell. The design aim is to eliminate any condensate buildup during shutdown. Practical solutions to the problem of maintaining tight-seating steam valves are given.

6. "Metallic Packing---Best for Gases," K. C. Wizeman; POWER, v 102, n 8, August, 1958, p 120.

   A comparison is made of the relatively maintenance-free service life of eight to ten years or more for metallic packing with the six months or a year of trouble-free operation you get from fibrous types. Installation of metallic packings is relatively simple; lubrication of metallic packings minimizes friction and prolongs service life. For pressures under 600 psig and with adequate lubrication, graphitic-bearing-type cast iron is suitable material; for higher pressures, a leaded-bearing-bronze is best. Nonlubricated service necessitates use of carbon for the segments. For corrosive service, babbitt and phenolics are good.

7. "You Can Control Piping Vibration," V. V. Cerami; POWER, v 101, n 5, May, 1957, p 115.

   Three ways to isolate piping vibration and to minimize its harmful effects are discussed. Vibration isolators can be put under the source of vibration (vibration mounts or pads under a compressor). The piping system can be isolated from the source of vibration by placing specially designed short lengths of flexible piping into the line on the discharge side of pumps and compressors. Finally, vibration hangers can be used as flexible anchors on piping; they offset forces set up by vibration and minimize the damaging effect.

8. "Plastic Piping for Ships," THE SHIPPING WORLD, v 136, March 20, 1957, p 301.

   This light thermoplastic piping (Durapipe) is able to stand temperatures up to 400° F and, thus, is adaptable for low temperature steam lines.

9. "A New Fitting for Hydraulic Pipe Lines," SHIPBLDR AND MAR ENG BLDR, v 64, January, 1957, pp 60-61.

   The fittings are satisfactory for a working pressure of 10,000 psi, under the correct conditions and with correct sizes of tube. The fittings are made from steel bar and

forgings to a suitable British Standard Specification, this being a manganese-toughened quality steel. The gripping ring, or cone, is made from a similar steel and is suitably heat-treated. Joints may be dismantled and re-assembled any number of times, provided the same sets of parts are assembled together.

10. "On the Quality Requirements for Steel Valves for Nuclear Power Plants," J. J. Kanter; SECOND NESC, paper n 57-NESC-33, 5 pp.

    The extensive use of corrosion resistant steels, the problems of sealing, and the specifications for forgings and castings entering in the procurement of the quality demanded from primary loop valves are discussed.

11. "Reduction of Interior Bead in Tube Welding," ENGRS DIGEST, v 17, January, 1956, p 4.

    Without an interior bead, the tubing has better physical properties, improved corrosion resistance, and greater formability. The outside-diameter weld bead can be held uniform and smooth so that it is possible to reduce it by swaging and to improve its mechanical properties without undesirable side effects.

12. "Endurance Testing of Expansion Joints," W. Samans and L. Blumberg; ASME, paper n 54-A-103.

    Stress concentrations at circumferential edge welds were the apparent primary cause of failure in all the disk-type joints tested. Stress concentrations in longitudinal welds were the apparent primary cause of failure in three of the hydraulically-formed types of joints tested.

13. "Nickel-Chromium-Molybdenum Steel Valve Casting After 50,000 Hours of Service at 900° F," T. N. Armstrong and R. J. Greene; ASME TRANS, v 73, 1951, pp 751-753.

    There has been no loss of strength, no embrittlement, and no occurrence of graphite in the welded valve casting of nickel-chromium-molybdenum steel, of approximately WC-4 grade, after exposure to steam at 900° F for a period of six years.

14. "Joints for High-Pressure High-Temperature Piping," I. H. Carlson and W. S. Black; ASME TRANS, v 73, 1951, pp 237-246.

    The special 10 inch, 1900 psi pressure-seal flanged pipe

joint remained tight throughout 25 cycles of heating to 1050° F and quenching with saturated steam at approximately 575° F. The special 10 inch, 1900 psi bellows-type flanged pipe joint leaked 11 times out of a total of 23 quench tests. Leakage was extremely slight; the joint sealed itself in every case. Final inspection showed the drilled 18-8 flange deformed 0.010 inch at the outer edge and 0.004 inch at the OD of the stellite-faced gasket chamber.

15. "Cyclic Heating Test of Main Steam Piping Joints Between Ferritic and Austenitic Steels---Sewaren Generating Station," H. Weisberg; ASME TRANS, v 71, 1949, pp 643-664.

A cyclic heating test of several full-size heavy-wall pipe joints between austenitic and ferritic steels is described. It is concluded that sound welded joints can be made between these dissimilar materials and that such joints will withstand the effects of temperature changes which may be expected to occur in modern power-plant service. The results provide considerable assurance that 18/8 piping, and particularly welds between 18/8 piping and low-chrome steel piping, can satisfactorily withstand the temperature changes.

PUMPS

1. "Pumps, Valves, Heat Exchangers for Water-Cooled Power Reactors," NUCLEONICS, July, 1961.

A resumé is given of the record of the canned rotor pump and limited leakage pumps, and some criteria are indicated in choosing one or the other. Further discussions treat value of experience, steam generator design, and fabrication considerations.

2. "PRTR Mechanical Seal Pump Operating Experience," P. A. Scott; HW-65724 (General Electric Co., Hanford Atomic Products Operation), August, 1960. Available from OTS and Depository libraries.

The experience of a PRTR primary process pump and of a second small pump using prototype seals is reported. The Plutonium Recycle Test Reactor (PRTR) is the first large high-temperature and pressure reactor to adopt low leakage mechanical seal type primary pumps. Circulating pumps with mechanically sealed shafts are satisfactory for use in the nuclear industry. They offer the advantages of a life equal to other pumps, relatively simple maintenance on-site, and low leakage rates. Maintenance experience of the pumps is also discussed.

3. "Sultan Centrifugal Pumps," MAR ENGR AND NAV ARCH, v 83, n 1007, May, 1960, p 199.

   The pump shaft is designed so that the span between the two bearings is always greater than the length of the cantilever from the impeller center-line to the first bearing. This gives a low bending moment and reduces shaft deflection to a minimum. Deep-groove ball bearings are used throughout, while bearing life is increased by the ballast chamber behind the impeller which minimizes any hydraulic axial thrust.

4. "Design Basis for Paddle Pumps," D. S. Webster and C. L. Williamson; DP-451 (Du Pont de Nemours and Co.), January, 1960, 23 pp. Available from OTS and Depository libraries.

   A paddle pump is a high-clearance centrifugal pump with a four-bladed paddle as an impeller. Their simple, rugged features make them desirable in radiochemical processing.

5. "Here's Why You Can Seal High Temperatures and Pressures," H. Tracy; POWER, v 103, n 9, September, 1959, p 220.

   A self-contained cooling system that reduces temperature at the seal faces without needing injection of cold condensate or makeup water is discussed. The rotating face has slots which act as a pump impeller or pumping ring. During operation, water in the stuffing box is pumped through the heat exchanger. Thus, it is cooled before flowing to the stuffing box adjacent to the seal contact surfaces. It is claimed that a boiler-feed pump equipped with these seals has been running for 26,500 hours, over three years, without any need for maintenance.

6. "Turbofeed Pump," MAR ENGR AND NAV ARCH, Annual Steam Number, v 82, 1959, pp 482-483.

   The rotor of this pump runs in water-lubricated journal bearings, the driving and pumping elements being overhung from the opposite ends of the shaft and contained in a steel casting which incorporates the turbine and pump casings without external openings. The maintenance problems which accompany oil lubricated bearings, shaft seals, and stuffing boxes are thus eliminated.

7. "Designing Pumps and Blowers for Nuclear Power Plants," R. A. Strub; NUCLEAR POWER, v 3, n 32, December, 1958, pp 592-594.

   Circulating pumps, compressors, and blowers exposed to radiation present unusual problems regarding operating

speeds, lubrication, and hermetic sealing. The effects on operation and maintenance of extremely high temperature, corrosion, and radiation are also considered.

8. "High Speed Pumps Feed High-Pressure Boilers," POWER, v 102, n 10, October, 1958, p 103.

   It is claimed that maintenance is reduced for the Worthington high-speed, barrel-type feed pump having 565,000 lb. per hour capacity at a discharge of 1810 psig and driven at a speed of 6500 rpm by a steam turbine. Maintenance is reduced because the shorter, more rigid shaft decreases wear at running joints. Pump life is greatly affected by shaft deflection and internal clearances. High-speed pumps have less than one-third the deflection of similar low-speed units.

9. "Rotary Pump Gland Sealing," MAR ENGR AND NAV ARCH, v 81, July, 1958, p 272.

   The T-Y gland, a product of Ronald Trust and Co., Ltd., has been in use for four years in various fields of engineering and has proved on centrifugal pump glands to have a good sealing efficiency without wear to pump shafts.

10. "High Temperature Mechanical 'Canned Motor' Liquid Metal Pumps," O. P. Steele, III; NESC (Chicago), preprint 76, Session II, March 17-21, 1958.

    This paper describes the features of a mechanical "canned motor" pump of an advanced design which appears to have excellent potential.

11. "New Type of Pump," SHIPBLDG AND SHIPG REC, v 91, February 20, 1958, p 242.

    A description is given of a new type Goodyear pump which is of the continuous, self-priming, self-lubricating type working with the Archimedian screw principle. There are three sizes of the pump ($1\frac{1}{4}$ inch, $1\frac{1}{2}$ inch, $2\frac{1}{2}$ inch suction and delivery connections) requiring prime movers of 1/3 to 16 bhp. They cover a range of outputs from 4.5 to 167 gallons per minute at a speed range of 750 to 3000 rpm. Its simplicity, portability, and extreme lightness make it an all-purpose pump of outstanding performance.

12. "How to Solve Soft Packing Problems," W. Coopey; CHEM ENGR, v 65, n 2, January 27, 1958, pp 131-134.

The improvement of the conventional pump packing design to obtain long packing and shaft life is discussed. The new design offers simplicity.

13. "Ingersoll-Rand Vertical Feed Pumps," MAR ENGR AND NAV ARCH, Annual Steam Number, v 81, n 988, 1958, p 500.

This advanced vertical double-case design with unit-type multi-stage rotor is designed to give sustained trouble-free operation over long periods of time. No external oil system is needed as the internal bearings are lubricated by the liquid being pumped.

14. "Care and Maintenance of Centrifugal Pumps," W. Weasing; ENGRS DIGEST, v 18, n 11, November, 1957, pp 493-497.

The reversing and racing condition should be considered in high-efficiency pump design. As the stuffing box is still the component with the lowest service life, designs of pumps without stuffing boxes have been developed for minimum maintenance. Typical causes of pump damage and erosion effects are given.

15. "500 GPM Electromagnetic and Mechanical Pumps for the EBR-II Sodium System," O. S. Seim and R. A. Jaross; SECOND NESC, paper n 57-NESC-94, 6 pp.

The mechanical pump employs a special hydraulic bearing fed by sodium from the impeller discharge. No bearings are required in the electromagnetic pump. The mechanical pump requires a flowing inert gas supply to its shaft seal, and the liquid level within the pump must be controlled. The electromagnetic pump requires neither of the latter, but does require a constant cooling fluid supply.

16. "Inspection of Byron Jackson 1800 RPM Pump After 580 Hours of Operation," E. A. Macha; WAPD-EM-88 (Westinghouse Electric Corp., Atomic Energy Div.), October 1, 1956, 27 pp. Available from OTS and Depository libraries.

The pump was shut down after a total of 580 hours at 100 psi. The results of the inspection were favorable. Graphitar runner and thrust bearing shoes appeared to be in good condition.

17. "Hydraulic Analysis of Sudden Flow Changes in a Complex Pumping Circuit," G. E. Alves; AICHE J, v 2, June, 1956, pp 143-147.

The hydraulic problems of a pump failure in complex hydraulic circuits are discussed. This analysis led to the decision not to install check valves but to employ brakes or non-reversing clutches to protect the system from the consequences of running the pumps as turbines.

18. "Electromagnetic Pumps for Nuclear Reactors," NUCLEAR POWER, v 1, May, 1956, pp 39-40.

    The paper describes different types of liquid metal pumps developed by British Thomson-Houston Co., Ltd. The main advantages of electromagnetic pumps over mechanical pumps are no moving parts, compactness, and equal if not better efficiency.

19. "Development of Glandless Pumps," J. R. Allard; NUCLEAR ENGRN, v 1, April, 1956, pp 28-30.

    The problems of glandless pumps are discussed. It is shown how two available pumps overcome these problems. Glandless pumps are used in nuclear engineering work because of their reliability and leak tightness. Impeller specific speeds of less than 3000 are preferred for the large sizes and less than 2500 for the smaller sizes.

20. "Which Heater Drain Pump, Vertical or Horizontal," T. W. Edwards; POWER ENGRN, v 60, n 4, April, 1956, p 90.

    The advantages of two basic-type pumps and their differences are compared with reference to efficiency, submergence requirements, maintenance, bearing life, operation during load change, and operating temperature.

21. "Pulsafeeder and Purge Pump Failures on the HRT Mockup," H. L. Falkenberry and I. Spiewak; CF-56-3-173 (Oak Ridge National Laboratory), March 1, 1956, 10 pp. Available from OTS and Depository libraries.

    Data on pulsafeeder and purge pump failures in the HRT mockup are summarized. Measures to prevent such failures are suggested.

22. "How to Select and Install Pump Seals," T. J. Sniften; PETROLEUM REFINER, v 35, n 3, March, 1956, pp 207-210.

    The paper gives synthetic materials for mechanical seals. Synthetic rubbers are satisfactory between -30° F and 200° F in liquids compatible to synthetic rubber. The

temperature range for fluorocarbon extends approximately from -120° F to 450° F, and fluorocarbon is resistant to attack by practically all liquids pumped in industry.

23. "Specify Eductor Vanes to Slash Cost of End Suction Process---Pump Maintenance," C. R. McFarland; POWER, v 100, n 2, February, 1956, pp 86-87.

The low-pressure area created at the impeller hub and stuffing box is only a fraction of the discharge pressure, increasing the life of the packing, shaft, or sleeve. Solids in suspension cause less trouble when handled by a pump having eductor vanes because fewer particles find their way into the stuffing box. This further reduces the wear and maintenance.

24. "Suppression of Pump Vibrations Set Up at Starting Up---Preopening Method," F. Numachi and Sendai; ASME TRANS, v 78, 1956, pp 1735-1740.

Cases occur in large water pumps wherein, after installation, vibrations exceeding allowable limits are found to set in when starting up. To meet such situations without resorting to reconstruction of the pump itself, a method of "pre-opening" is presented in this paper. This consists of opening up the delivery valves to a certain extent while the pump is gradually being worked up to full speed. The method of estimating the quantity of reverse flow, the torque required, and the time necessary for attainment of normal speed is explained.

25. "Pulsation Absorbers for Reciprocating Pumps," E. G. Chilton and L. R. Handley; ASME TRANS, v 77, 1955, pp 225-230.

Pulsation absorbers (or surge tank) are often required in reciprocating-pump installations where pipe vibration, flowmeter errors, partial flashing of the liquid in the low-pressure ranges, valve hammer, and other disadvantages of pulsating flow must be eliminated. Graphs are presented based on theoretical analyses for sizing such absorbers for any given installation and desired pulsation amplitude. Experiments with a laboratory unit as well as a few full-scale plant installations confirm the theoretical results. Recommendations also are made for certain important design details.

26. "Mechanical Pumps for High-Temperature Liquid Metals," P. M. Clark; ASME, paper n 52-A-94.

The liquid metal pump design, associated seal development, and operating experience are described in this paper. Each pump is a single volute, radial centrifugal design with a 926 specific speed, rated 400 gpm, and 126 ft. head at 1750 rpm.

27. "Corrosion-Erosion of Boiler Feed Pumps and Regulating Valves," H. A. Wagner, J. M. Decker, J. C. Marsh; ASME TRANS, v 69, 1947, pp 389-403.

Tests indicate that resistance to corrosion-erosion is materially increased by using chromium-bearing alloy steels. Bronzes and monel are resistant to attack and, to a lesser extent, so is cast iron. Results obtained with a bakelite-lacquer-coated carbon-steel specimen indicated that this coating has considerable promise for use with present boiler feed pumps having cast-carbon-steel casings.

28. "Cavitation in Centrifugal Pumps," A. J. Stepanoff; ASME TRANS, v 67, 1945, pp 539-552.

The life of pump parts can be increased considerably by using special materials such as aluminum, chrome-vanadium steel, and steel N-123.

29. "Testing of HNPF Freeze-Seal Pump," R. W. Atz; NAA-SR-4387 (North American Aviation, Inc., Atomics International Div.), 48 pp. Available from OTS.

Objectives of the program were to test two pumps of different design and to develop auxiliary components which were needed. This report describes the testing of a freeze-seal pump; included in the appendix is the account of the development of a special shaft freeze seal for use in this pump. Operating design conditions for the test pump were for pumping sodium at 7200 gpm, 945° F, and 150 ft. head. A separate report (R. W. Atz, NAA-SR-4336, to be published) will cover work done on the second pump, namely the free-surface type, in which there is no shaft seal.

30. "Development of Special Pumps, Their Power Supply, Valves, Bearings, and Instrumentation for Liquid Metals," E. F. Brill (Allis-Chalmers Mfg. Co.); ASME, paper, no number, available only from the author.

The paper discusses the several types of these pumps that have been developed and the uses for leakless pumps for high pressures and temperatures. Among the pumps are the

hermetically sealed designs, of which three types have been built. They are the canned induction motor, unipolar motor, and turbomagnetic drive. Bearings, valves, liquid-level indicators, liquid-level controllers, flowmeters, and pressure measurements are also discussed.

STEAM PLANTS, STATIONARY

1. "Study of Outage Experience with Selected Boiler and Turbine Generator Units," M. L. Myers; CF-60-3-56 (Oak Ridge National Laboratory), March 31, 1960. Available from OTS and Depository libraries.

   A very good paper, but the information is not to be abstracted, reprinted, or otherwise given public dissemination without the approval of the Oak Ridge National Laboratory patent branch.

2. "Update Your Preventive Maintenance Thinking to Stay in Orbit," S. Elonka; POWER, v 103, n 11, November, 1959, p 191.

   "Diagnostic," "total destruction," and "spot checking" mean increased production in the space age maintenance man's dictionary. A general discussion of the maintenance problem is included.

3. "Equipment and Design Aids Roundup," POWER, v 103, n 10, October, 1959, p 229.

   A 37-page survey is presented of the latest power-service equipment and design aids on electrical generation, electrical distribution, electrical applications, heat exchange, lubrication, materials handling, prime movers, welding, compressors and accessories, pumps, steam generation, valves, piping fittings, mechanical power transmission, water treatment, and instrumentation.

4. "Rotary Regenerative Air Preheater," J. Waitkus; MARINE NEWS, v 46, September, 1959, pp 22-23, 68.

   An important feature of the heating surface design is the removability of the cold end layer if and when it is necessary to do so for servicing and replacement. The entire cold end layer can be replaced with a minimum of expense in material and labor and at a fraction of the cost of the entire surface. The hot end layer never needs replacement under normal operating conditions. The most interesting characteristic of the rotary regenerative process of heat

exchange is its freedom from the influence of deposits on the efficiency of heat transmission.

5. "Planned Maintenance Pays Off in Minimum Downtime," L. S. Ries; HEATING, PIPING, AND AIR CONDITIONING, v 31, n 7, July, 1959, pp 120-121.

    To prevent downtime of the boiler, it is annually inspected and overhauled. Extensive records and planned maintenance allow the system to operate with only one boiler.

6. "Rotary Regenerative Air Preheaters," J. Waitkus; MAR ENGRN/LOG, v 64, March, 1959, pp 71-73.

    With rotary regenerative air preheaters, low exit-gas temperatures with resulting high boiler efficiencies have been achieved without undue maintenance problems. In raising the combustion air temperatures to 550° F, a marked reduction of SO_3 can be obtained. Thus, corrosion and plugging problems caused by SO_3 in the furnace can be reduced.

7. "Minimum Recommended Protection for Unit-Connected Steam Stations," AIEE working group; AIEE, paper n CP-59-878.

    Over-all protective schemes, considered by the working group to be a minimum, cover the steam generator, steam turbine, generator, main transformers, and auxiliary systems.

8. "Computer Calculates Heat Rates to Set Economic Turbine Overhauls," C. F. Whitmer and W. M. Stephens; ELECTRICAL WORLD, v 149, n 1, January 6, 1958, pp 44-45.

    Turbine test data, obtained primarily by conventional plant instruments, were processed in an IBM 650 computer which solved 79 equations to obtain the desired heat rates. It could then be decided whether an anticipated improvement in heat rate would save sufficient fuel to justify the cost of a major overhaul.

9. "Relay Protection Practices in Steam Power Stations," H. C. Barnes; AIEE, paper n 58-1106.

    This report presents particular features of central-station protection, emphasizing the problem of dependability and the need for coordination of all protective devices in a station ---mechanical as well as electrical. The amount of protection, safeguards, generator protection, voltage regulators, turbine protection, transfer of auxiliaries, backup protection,

and maintenance are subjects also covered.

10. "Operating Experience with High-Temperature Steam Turbine Rotors and Design Improvements in Rotor Blade Fastening," J. D. Conrad and N. L. Mochez; ASME, paper n 57-PWR-10, October 21-23, 1957, 51 pp.

    The improvement of high-temperature rotors and blades of steam turbines is treated with regard to design change for better cooling, stress reduction of blade roots, and improved heat treatment of chromium-molybdenum-vanadium steel (austinizing at 1750° F).

11. "Deionization of Feedwater," THE SHIPPING WORLD, v 137, September 18, 1957, p 248.

    By the installation of a large deionization plant, the CO_2 in the feedwater can be extracted with a resulting reduction in boiler corrosion.

12. "Titanium Condenser Tubes," ENGRN AND BOILER HOUSE REVIEW, v 72, March, 1957, pp 75-76.

    Trials are now being carried out on the first titanium condenser tubes ever to be fitted to condensers; they are installed in a British power station. It is claimed by leading suppliers that titanium has a phenomenal resistance to many corrosive media, particularly sea water.

13. "Importance of Matching Steam Temperatures with Metal Temperatures during Starting of Large Steam Turbines," R. L. Jackson, S. B. Coulter, R. Sheppard; ASME TRANS, v 79, 1957, pp 1669-1678.

    Turbine designs are improved to allow faster starting rates. With proper temperature control of the metal sections, turbines can be brought to speed and fully loaded in times as short as 30 minutes after an eight-hour shutdown. However, the temperature gradient across turbine metal walls should be limited to 150° F.

14. "Experimental Superheater for Steam at 2000 psi and 1250° F---Report after 14,281 Hours of Operation," J. H. Hoke and F. Eberle; ASME TRANS, v 79, 1957, pp 307-317.

    The various alloys used in the test had no serious deterioration of the essential properties. The oxidation resistance of all alloys appears to be adequate for the service for which they were employed. The nonstabilized alloys 304 and

316 suffered no intergranular attack. The test result indicates that materials are available for use in superheaters for high-pressure steam up to 1250° F.

15. "New Problems in Auxiliary System Design---Supercritical Pressure and Nuclear Plants," C. J. Baldwin, Jr.; AIEE, paper n 57-51.

    The two new developments in power generation, supercritical pressure cycles and nuclear reactors, are imposing additional requirements on power-house auxiliary systems. This paper discusses the plant heat cycles from the auxiliary system viewpoint, outlines the auxiliary system requirements, and gives typical solutions used by plants in the design and construction stages.

16. "Forced Outage Rates of High-Pressure Steam Turbines and Boilers," AIEE Joint Subcommittee on Application of Probability Methods to Power System Problems; AIEE, paper n 57-145.

    This report is a presentation of the final results of a five-year nationwide outage survey of horizontal steam turbine-generators and of boilers. The horizontal steam turbine-generators operate at pressures of 700 psi or greater and are rated at or over 20,000 kw condensing or 10,000 kw superposed. The boilers have a continued rated capacity of 200,000 lb. per hr. or more and outlet pressures of 700 psi or greater. The objective of the study was to obtain forced outage rates of the equipment for use in applying probability methods to power system problems involving such facilities.

17. "Control of Spray Water to Reheater Attemperators," I. J. Karassik; SOUTHERN POWER AND INDUSTRY, v 74, n 11, November, 1956, p 44.

    The use of spray attemperation as a temperature control of reheated steam is discussed along with a means to control the quantity of spray water. A method is suggested by which orifices cut pressure drop and reduce valve maintenance.

18. "New Boiler Design for Liner," THE SHIPPING WORLD, v 135, August 29, 1956, pp 187-188.

    The principal feature of interest in the design is the use of an external superheater. Its location (after the main tube bank) is designed to limit the gas temperatures to the superheater elements in order to reduce the tube metal temperatures and also to avoid the associated problems of slagging, support plate corrosion, and the like.

19. "Design Aspects of an Electrostatic Precipitator for the Collection of Small Solids Ahead of the Air Heater," H. Klemperer and J. E. Sayers; ASME TRANS, v 78, 1956, pp 317-326.

The development of a novel electrostatic precipitator is described which operates in the temperature range between 500° F and 7500° F, at a gas velocity of 40 fps. A stream of cleaning is continuously moving from one sector to the other to carry deposited dust into a secondary cyclone-type collector.

20. "New Amine Treatment, Combined with Industrial pH Meter, for Boiler Feedwater," SHIPBLDR AND MAR ENG BLDR, v 62, October, 1955, p 613.

The boiler feedwater should be treated with a volatile amine which would pass over with the steam to ensure that the condensate remained slightly alkaline. By this means, corrosion in the steam, condensate, and feed systems (including the cargo-heating coils) would be stifled. Also, the pH value of the condensate should be measured at frequent intervals. The pH meter selected for this was the No. 28 model of the Electronics Ins., Ltd., Richmond, Surrey.

21. "Is Chemistry in the Power Plant an Exact Science," F. Neat; ASME, paper n 55-S-38.

The items discussed include caustic embrittlement, oxygen scavenging, pitting corrosion, ammonia in the system, alkalinity, hide out, and acid cleaning.

22. "Causes of Breakdown in Steam Plant," I MECH E PROC, v 164, 1951, pp 129-136.

The informal discussion on the causes of breakdown in steam plants was introduced by ten speakers, each of whom made a contribution based on his own experience. The subjects were loose wheels on the turbine shaft, pressure vessels, failure of brush turbine, corrosion fatigue, scaling of water side of condenser tubes, failure of the high-pressure shaft of a 25-megawatt turbine, failure of joint of dome head of high-pressure preheater, and general failures.

23. "Sealing of High-Pressure Steam Safety Valves," R. E. Adams and J. L. Corcoran; ASME TRANS, v 72, 1950, pp 1137-1142.

When tested with steam, leakage with the new design at 4% below the popping point was as low as with the conventional valve seat at 12% below the popping point. The seat was

subjected to a test of 80,000 cycles to determine whether or not fatigue of the seat element would develop. At the end of the test, the disk and seat were still structurally perfect and showed no signs of fatigue failure.

24. "Boiler Nozzles and Valve Inlets for Maximum-Capacity Safety Valves," E. K. Falls; ASME TRANS, v 67, 1945, pp 133-140.

    This paper introduces a safety-valve design which would be capable of discharging the greatest amount of fluid that could flow through a given size inlet within the limitations imposed by entrance conditions of pressure and either temperature or quality. Conditions were determined which would guarantee satisfactory performance.

25. "Air-Heater Facts: 1926-1941," E. L. Hopping and D. F. Schick, Jr.; ASME TRANS, v 64, 1942, pp 219-225.

    Details are given covering the selection of air heaters, corrosion problems, methods of eliminating corrosion, cleaning air-heater units, and troubles experienced with air-heater installations. Corrosion of air heaters, due to condensation of moisture carried by the flue gas, is prevented by providing a direct air by-pass duct for the air heater.

STEAM TURBINES

1. "Operation of Steam Turbines to Minimize Shell Cracking," S. B. Coulter and R. L. Jackson; ASME, paper n 59-PWR-10, September 27-30, 1959, 16 pp.

    Shell cracking in steam turbines is minimized by improved operating procedures and the application of accessories to control shell-temperature differentials. One successful design has the cast-nozzle port passages so arranged as to be free of the main bulk of the horizontal joint. The insert-steam-chest or nozzle box is designed to minimize cracks, allow freedom for three-directional thermal expansion, use relatively thin walls, and simplify casting design. The bypass method of starting and loading is one of the most effective methods for the prevention of excessive thermal stresses. Methods of operation include stop-valve bypass, start with low boiler pressure, start on existing stop-valve pilot, special valve cams for simultaneous control-valve opening, flange heating, and nozzle-bridge cross drilling.

2. "Advanced Developments in Component Design for Large Steam Turbines," H. R. Reese; WESTINGHOUSE ENGR, v 19, n 4, July, 1959, pp 98-101.

In view of the increasing complexity of turbine design, a better approach than "custom engineering" is possible through advanced development of components and associated turbine equipment. The advantages of pre-engineering include greater manufacturing reliability.

3. "EBWR Turbine Blade Failure," J. M. Harrer and E. A. Wimunc; ANL-5941 (Argonne National Laboratory), November, 1958, 22 pp. Available from OTS and Depository libraries.

Inspection indicated that the blade fracture probably resulted from fatigue of the root metal. The failure was progressive and occurred in stages across the root to the leading edge of the blade. Before replacing the blades, the manufacturer deepened the blade-root groove in the wheel so that a soft iron caulking piece could be driven under the blade root to maintain a tight fit. Vibration was minimized or eliminated by this expedient. All blades were shot peened at the roots to improve fatigue strength.

4. "Control and Safety Gear of Large Steam Turbines," A. Oberle; BROWN BOVERI REVUE, v 45, n 7-8, July-August, 1958, pp 325-338.

Solutions for control and safety problems of large steam turbines are given along with control of interceptor valves. Treatment is also extended to acceleration regulator, leak-off amplifier, feed heater flaps, load selector tripping and test gear, starting valve, preventing flow of steam and water from feed heaters to turbine, protection against vacuum failure, protection against lubrication system failure, and magnetic trip gear.

5. "Electrostatic Shaft Voltage on Steam Turbine Rotors," J. M. Gruber and E. F. Hansen; ASME, paper n 58-SA-5, June 15-19, 1958, 10 pp.

Electrostatic voltage damaged the bearings; direct-current voltages are probably being generated on all condensing turbines by the action of the wet steam on the rotating elements. The solution to the problem is grounding the voltage without causing bearing damage rather than trying to eliminate the generation of the voltage at the source. Grounding proposals include carbon brushes, metallic shoes, mercury baths, water seals, lubricating oil with high conductivity, and ionized air paths. The effects of the d-c voltage could be eliminated by applying an equal and opposite polarity voltage.

6. "Failure of a 60-MW Steam Turbo-Generator at Uskmouth Power Station," A. L. G. Lindley and F. H. S. Brown; I MECH E PROC, v 172, 1958, pp 627-653.

The paper presents in ordered sequence the conclusions reached as a result of the investigations. The reasons for failure center on the presence of black iron oxide in the oil system and the way in which it builds up on working surfaces of pistons and cylinder bores of the governor.

7. "Long-Life Monel Turbine Blades," MAR ENGR AND NAV ARCH, v 81, n 988, 1958, p 489.

The paper discusses the high-pressure turbines which were fitted with Monel blades. These blades have not been replaced for 26 years, and when the turbines were opened up recently for inspection, they were found in good condition and fit for further service. The remarkable ability of Monel to stand up to the corrosive and erosive effects of superheated steam is well demonstrated by the life obtained from this blading.

8. "Extend Turbine Blade Life with Metal Spray," G. C. Paraskeva and G. J. Taylor; POWER ENGRN, v 61, n 8, August, 1957, pp 68-69.

A method of arresting turbine low pressure blade erosion, developed by Akron Sand Blast and Metallizing Co. in conjunction with Ohio Edison Co., consists of metal spraying of molybdenum base coating and a protective coating of 4-20 stainless steel. A method of grinding valve flanges after spraying is also discussed.

9. "Here Is a Quick Review of Turbine Sealing Methods," H. E. Morgan; POWER ENGRN, v 61, n 7, July, 1957, pp 78-79, 94.

The features of the labyrinth seal designed for modern turbine operation and the use of carbon rings in combination with the labyrinth seal acting as pressure breakdown are given, along with the complete gland seal for shaft ends and the exhaustor system. The use of brushing and flexible metal packing to prevent leakage at valve stems and multiple bushing or the floating ring seal assembly for a range beyond 850 psig and 1000° F are also discussed.

10. "Technical Progress in Steam Turbine Design," L. S. Robson; ENGINEER, v 203, n 5292, June 28, 1957, pp 978-980.

The turbine's final stage blading must be twisted to give

suitable inlet and outlet angles along its length and to reduce bending stresses due to centrifugal pull; the locus of the center of gravity at the section should approximate a straight line. For high temperatures, austenitic steel of the 18% chromium, 12% nickel, and 1% niobium type is used. Development of ferritic steel of 6% and 12% chromium alloyed with elements as titanium, vanadium, and niobium was achieved to give high creep resistance. Casings for high pressures and temperatures employ double-shell construction. With inserted nozzle boxes for high pressures and temperatures, the casing is exposed to the reduced values which obtain after the first stage. Castings are used more than forgings for casings.

11. "Air-Drying Steam for EBWR Turbine Seals," E. L. Young; NUCLEONICS, v 15, n 4, April, 1957, pp 105, 108.

A discussion is given of how the drying and moisture recovery system was applied to the Experimental Boiling Water Reactor steam plant at Argonne National Laboratory and was found to prevent loss of valuable moderator and escape of radioactivity to the atmosphere. The system is automatic and remote controlled. A schematic diagram of the type of seal developed for the 5000 kw turbine and the drying and moisture recovery system is included. The sealing arrangement, with modifications, can be applied to reactor pumps and turbine horizontal joint flaps.

12. "Application of Research to Design of Marine Steam Turbines," T. W. F. Brown; I MAR E TRANS, v 69, n 3, March, 1957, pp 65-93.

Research and progress needs in marine engineering are shown in this review of ten years' work. The subjects handled include comparisons of designs resulting from research in 1945 and 1953, development of turbine blading, turbine configuration and details with particular reference to casing construction, diaphragms, glands, water extraction in low pressure stages, bearings and vibration of rotors, and gearing research and tests.

13. "German Marine Steam Turbines," T. Schwarz, Schiff, Hafen; MAR ENGR AND NAV ARCH, Annual Steam Number, v 80, 1957, pp 484-490.

The Siemens two-casing turbines are discussed. By arranging the ahead and astern maneuvering valves together on the top of the HP casing, a separate steam chest is unnecessary and only one steam supply pipe is required. Thus, the number of flanged connections in live steam piping is reduced to a minimum.

14. "Fire-Resistant Turbine Fluids Bow In," J. J. O'Connor; POWER, v 99, n 3, March, 1955, p 75.

A discussion is given of four materials or approaches that are now available or show promise as contenders for the fire-resistant label: phosphate esters, hydrolubes, oil plus a "snuffer," and silicone fluid in combination with some suitable material.

15. "Turbine Blade Vibration and Strength," W. E. Trumpler, Jr. and H. M. Owens; ASME TRANS, v 77, 1955, pp 337-341.

This paper is instructive to the marine-turbine designer who is constantly faced with the problem of providing adequate strength to resist vibrating forces whose magnitude he does not know.

16. "Turbine Supervisory Instruments," J. C. Spahr and R. L. Richards; ASME, paper n 55-A-62.

The operation and function of a complement of current turbine supervisory instruments are described. The instruments are the shaft-eccentricity meter, cylinder-expansion meter, differential-expansion meter, flange differential-temperature meter, shaft-position meter, thrust meter, and vibration meter.

17. "The Elastic Fluid Centripetal Turbine for High Specific Outputs," R. Birmann; ASME TRANS, v 76, 1954, pp 173-187.

The centripetal turbine can be designed to handle larger flows and higher enthalpy drops at higher rpm with better efficiency and lower stresses than does the axial-flow turbine. It is simpler and cheaper to manufacture, and it is more rugged because of the low number of blades and their configuration. Blades and hub can easily be made a single piece, eliminating the age-old difficulties with blade fastenings. Blade and hub can be air-cooled effectively in a simple manner, permitting operation with very high gas temperatures for which the strength of uncooled metal would be insufficient.

18. "Silica Deposition in Steam Turbines," F. G. Straub and H. A. Grabowski; ASME TRANS, v 67, 1945, pp 309-316.

The tests indicate that the silica leaves the boiler as vaporized silicic acid which later crystallizes on the blades in the lower-pressure stages of the turbine. When the silica in the steam is below 0.1 ppm, no appreciable

deposits are found in the turbines. To prevent deposits, maintain the silica in the boiler water below 5 ppm and remove the silica from the steam by scrubbing with a pure-grade water.

MISCELLANEOUS

1. "Performance of Some Modern Gasket Material," MECHANICAL WORLD AND ENGINEERING RECORD, v 141, n 3503, June, 1961, pp 208-210.

    The range of modern gasket materials available provides ample scope for choice of compressibility, sealing pressure, physical performance, and chemical inertness. The basic factors governing the performance and selection of resilient seal materials and the properties of some typical modern compositions are given. A selection chart for gasket materials for different fluids is also given.

2. "The Marine Ionostat," MAR ENGR AND NAV ARCH, v 82, n 1002, 1959, pp 491-494.

    The marine ionostat uses resins which are essentially matrices of styrene-divinyl benzene co-polymer employing active centers of nuclear sulphonic acid and complex hydroxyl groups. The ionostat requires little attention and eliminates the ever present human element to a very high degree. It is very simple to operate and requires no acid for regeneration.

3. "Self-Excited Vibration of Axial-Flow Compressor Blades," A. D. S. Carter and D. A. Fitzpatrick; I MECH E PROC, v 171, 1957, pp 245-281.

    The main objective is to determine the major factors governing the axial-flow compressor blade vibration and to establish some design rules which would reduce the chances of a failure to an acceptable minimum. A semi-empirical design rule is suggested, and its interpretation in terms of the normal blade design parameters is included.

4. "Coatings, Fire and Heat Resistant (Nonceramic), 1929-1955," CTR-316 (Catalog of Technical Reports), October, 1955, 4 pp. Available from OTS.

    The 34 references, some annotated, to available literature cover both domestic and foreign literature.

5. "Here's Latest on Mechanical Packing," S. Elonka; POWER, v 99, n 3, March, 1955, p 107.

This 24-page report discusses in detail packing types, packing shape and stuffing box design, and causes of packing problems and their prevention.

6. "Liquid Springs: Progress in Design and Application," A. E. Bingham; I MECH E PROC, v 169, 1955, pp 881-896.

Liquid springs are used on commercial machines and naval, military, and research apparatus. There is no doubt that the competition introduced by the liquid spring against the oleo-pneumatic shock absorber caused substantial advances in the latter. If the loads are very heavy and the space is limited and maintenance is a consideration, the liquid spring has the advantage. The liquid spring, once it is assembled, is extremely robust and no harm will overtake the incautious fitter when dismantling one. It is adaptable to widely varying conditions.

7. "Bryce Marine Hydraulic Governor," MAR ENGR AND NAV ARCH, v 77, n 932, August, 1954.

This governor was developed to meet the demand for a reliable, long-lived unit having characteristics suited to marine operation. The only rotating parts in this type of governor are the two gear pumps. There are no heavy rotating weights and nothing likely to give trouble, as are corresponding components of the centrifugal governor mechanism.

8. "The Control of Fouling Organisms in Fresh- and Salt-Water Circuits," J. G. Dobson; ASME TRANS, v 68, 1946, pp 247-265.

Mollusks, bryozoa, sponges, barnacles, and tunicates are considered. Their control can be effected by heat, change of salinity, change of oxygen content, increased velocity, acids, antifouling paints, screening, and poisoning with a number of different poisons. It is concluded that chlorination is the most effective and economical of these methods.

9. "Neoprene as a Spring Material," F. L. Yerzley; ASME TRANS, v 62, 1940, pp 459-478.

The mechanical properties of neoprene which are important for vibration, isolation, and damping are evaluated and compared with the analogous properties of rubber. Neoprene mountings are not damaged by millions of cycles of loading

and unloading, and they resist deterioration from oils, chemicals, heat, sunlight, and oxidation. This type of spring frequently eliminates guides and other points of metal-to-metal contact, thereby reducing maintenance costs.

REJECTED ARTICLES

1961

1. "Corrosion of Tin Base Babbitt Bearings in Marine Steam Turbines," J. B. Bryce and T. G. Roehner; I MAR E, abstract in supplement to TRANS, v 73, n 3, March, 1961.

2. "Giant Gas Turbines Get Overhauling in First Turnaround of PCI's Ethylene Plant," J. E. Fenex, Jr., H. Sims, P. M. Ableson; OIL AND GAS J, v 59, n 4, January 23, 1961, pp 74-76.

3. "Marine Engineering in 1960," BRIT MOTORSHIP, v 41, n 486, January, 1961, pp 460-464.

4. "Development Tests of First Doxford 67PT6 Engine," R. Atkinson; BRIT MOTORSHIP, v 41, n 486, January, 1961, pp 434-435.

1960

5. "Design Aspects of Modern Marine Propulsion Turbines," E. C. Rohde; SNAME, paper n 3, November 17-18, 1960, 19 pp.

6. "Corrosion of Mild Steel by Combustion Gases," T. K. Ross, A. J. MacNab, B. E. Leyland; I FUEL J, v 33, November, 1960, pp 540-542.

7. "What to Consider When Designing Nuclear Piping Systems," HEATING, PIPING, AND AIR CONDITIONING, v 32, n 11, November, 1960, pp 153-168.

8. "Microcracked Chromium," BATELLE TECHNICAL REVIEW, v 9, n 8, August, 1960, pp 15-16.

9. "Operational Experience with the MORAR," SHIPBLDR AND MAR ENG BLDR, v 67, July, 1960, p 414.

10. "Lubrication Problems of Internal Combustion Engines," LUBRICATION ENGRN, v 16, July, 1960, pp 315-320.

11. "Water Turbine-Driven Ballast Pump," MAR ENGR AND NAV ARCH, v 83, June, 1960, p 249.

12. "Phone Call Starts Britain's First Automatic Peaking Station," ELECTRIC LIGHT AND POWER, v 38, n 10, May 15, 1960, pp 102-104.

13. "Dry Fluid Centrifugal Coupling," SHIPBLDR AND MAR ENG BLDR, v 67, May, 1960, p 341.

14. "Present and Future Marine Gears," MAR ENGR AND NAV ARCH, v 83, n 1007, May, 1960, pp 220-224.

15. "Lessons Arising from Machinery Failures," H. N. Pemberton;

SHIPBLDG AND SHIPG REC, v 95, n 15, April 14, 1960, pp 483-484.

16. "Comparative Study of Some Reactor Systems for Marine Propulsion," R. P. Kinsey and H. W. Bowker; MAR ENGR AND NAV ARCH, v 83, March, 1960, pp 122-127.

17. "Non-Metallic Materials Used in Shipbuilding," L. W. A. Rayner; read at a meeting of NECIES, v 76, February 26, 1960, p 267.

18. "Use of Short Time Tests to Learn Long Time Material Behavior," H. L. Young; ASNE J, v 72, n 1, February, 1960, pp 101-107.

19. "Technical Progress in Marine Engineering during 1959," SHIPBLDR AND MAR ENG BLDR, v 67, n 624, January, 1960, pp 31-37.

20. "Rudder Pintle with Micarta Bushing," MAR ENGRN/LOG, v 65, January, 1960, p 106.

21. "The Effect of Electrical Grounding Systems on Underground Corrosion and Cathodic Protection," B. Husock; AIEE TRANS, v 79, Pt II, 1960, pp 5-10.

22. "Marine Engineering Review---Past, Present and Future," T. W. F. Brown; INA TRANS, v 102, 1960, pp 391-434.

23. "Vibration Problems in Marine Engineering and Their Solution," W. McLaughlin; IESS TRANS, v 103, 1960, pp 136-251.

1959

24. "Oil Cargo Pump Seal," THE SHIPPING WORLD, v 141, December 16, 1959, p 430.

25. "Investigation of Engine Mounting System," GAS AND OIL POWER, v 54, n 658, December, 1959, pp 324-325.

26. "Cell for Direct Production of Electricity from Fuel," ENGRS DIGEST, v 20, December, 1959, p 475.

27. "Machinery for Large Tankers," G. B. Bailey; NECIES TRANS, v 76, Pt I, November, 1959, pp 21-56.

28. "Machinery of the ROTTERDAM," MAR ENGR AND NAV ARCH, v 82, n 1000, November, 1959, pp 381-385.

29. "Pametrada Progress during 1958," MAR ENGR AND NAV ARCH, v 82, n 999, October, 1959, pp 351-353.

30. "Economics of Steam Vs. Diesel Tankers," R. T. Simpson; MAR ENGRN/LOG, v 64, October, 1959, pp 73-79, 128.

31. "Free Piston Gas Operating Compressor," GAS AND OIL POWER, v 54, October, 1959, p 264.

32. "Use of Flow Models for Boiler Furnace Design," R. W. Curtis and L. E. Johnson; ASME TRANS, SERIES A, J OF ENGINEERING FOR POWER, v 81, October, 1959, pp 371-377.

33. "Statistical Analysis of Reactor Safety Standards," E. Siddall; NUCLEONICS, v 17, n 2, September, 1959, p 64.

34. "High Powered Diesel Engines for Marine Propulsion," F. Schmidt; INTERNATL SHIPBLDG PROGRESS, v 6, n 61, September, 1959, pp 415-425.

35. "Gas Turbine for Liberty Ship," MAR ENGR AND NAV ARCH, v 82, n 998, September, 1959, pp 353-356.

36. "Maintaining Superior Weld Quality in Plutonium Production Plant," C. D. Brons; BRIT WELDING J, v 38, n 9, September, 1959, pp 853-859.

37. "A.G.R. Boilers," E. F. P. Bennett; NUCLEAR ENGRN, v 4, n 40, July-August-September, 1959, pp 291-293.

38. "Ship Propulsion by Means of Free Piston Gas Turbines," A. S. Anneveld; INTERNATL SHIPBLDG PROGRESS, v 6, June, 1959, pp 265-269.

39. "Pressure Vessel Design," J. L. Mershon; BUREAU OF SHIPS J, v 8, June, 1959, pp 38-39.

40. "Design Studies for Stern Trawlers," H. Heinsohn; read at the second WORLD FISHING BOAT CONGRESS (Rome), April 5-10, 1959.

41. "Prevention of Steel Stack Corrosion and Smut Emission with Oil-Fired Boilers," H. A. Blum and L. K. Rendle; I FUEL J, v 32, n 219, April, 1959, pp 165-171.

42. "Hazards and Safety Measures Related to Nuclear-Powered Merchant Ships," M. K. White; ALI-51, March 30, 1959, 91 pp.

43. "Exhaust Gas Boiler for 15,000 bhp Engine," BRIT MOTORSHIP, v 39, n 466, March, 1959, p 596.

44. "Shot Peening in Relation to Gear Tooth Scoring," J. C. Stroub; LUBRICATION ENGRN, v 15, March, 1959, pp 106-109, 119.

45. "Injection Inspection---Easy Way," DIESEL POWER, v 37, n 2, February, 1959, pp 26-27.

46. "Eliminating Gear Wear on C4 Vessels," J. J. Murphy; MAR ENGRN/LOG, v 64, February, 1959, pp 79-81, 132B.

47. "High Speeds Recorded on Preliminary Sea Trials," OIL ENGINE AND GAS TURBINE, v 26, mid-January, 1959, p 363.

1958, pp 56-57.

64. "Recent Developments in United States in Field of Commercial Ship Propulsion," R. P. Godwin; INTERNATL SHIPBLDG PROGRESS, v 5, n 47, July, 1958, pp 309-315.

65. "Supercharged Boilers for Marine Application," E. L. Daman; I MAR E TRANS, v 70, n 7, July, 1958, pp 241-249, 250-259 (discussion).

66. "Modern Safeguard for Automatic Boilers," P. E. Buday; ASME, paper n 58-SA-50, June 15-19, 1958, 5 pp.

67. "Detecting Oil Contamination Electronically," BRITISH COMMUNICATIONS AND ELECTRONICS, v 5, June, 1958, p 450.

68. "Technical Progress in Marine Engineering during 1957," ASNE J, v 70, n 2, May, 1958, pp 219-229.

69. "Water Lubricated Bearings for Marine Use," A. D. Newman; paper read at a meeting of NECIES, v 74, March 31, 1958, p 357.

70. "Welded Castings Keep Turbines Humming," R. N. Williams; INDUSTRY AND WELDING, v 31, n 2, February, 1958, pp 36-37, 60.

71. "Free Piston Engine: Power Plant with a Future," C. E. Wise; MACHINE DESIGN, v 30, January 23, 1958, pp 22-24.

72. "Design and Development of Four Light-Weight High-Speed Marine Gas Turbines for Electric Generator Drive," A. W. Pope; paper presented at a general meeting of I MECH E (London), January 10, 1958.

73. "Heat Balance Calculations and Their Use in Installation Design of Steam Turbine Merchant Ship Propulsion Machinery," E. Tyrrell; I MAR E TRANS, v 70, n 1, January, 1958, pp 1-20, 21-36.

74. "Purification of Heavy Oil," A. Brunner; SULZER TECHNICAL REVIEW, v 40, n 4, 1958, pp 47-58.

75. "Operational Data and Experience from the Experimental Boiling Water Reactor," J. M. Harrer; AUSTRALIAN ATOMIC ENERGY SYMPOSIUM, Argonne National Laboratory, 1958.

1957

76. "Combined Gas-Turbine/Steam-Turbine Cycle with Supercharged Boiler and Its Fuels," A. O. White; ASME, paper n 57-A-264, December 1-6, 1957, 20 pp.

77. "Recent Developments in British Naval Main Propulsion Steam Turbines," F. J. Cowlin and A. F. Veitch; I MAR E TRANS, v 69, n 12,

December, 1957, pp 497-518, 519-525 (discussion).

78. "The Marine Oil Engine," C. C. Pounder; presented at a meeting of NECIES, v 74, November 1, 1957, p 41.

79. "Reactor for Direct Conversion of Nuclear Energy into Electric Power," S. A. Colgate and R. L. Aamodt; ENGRS DIGEST, v 18, n 11, November, 1957, p 505.

80. "Method of Recording Vibrations in Turbogenerator Foundations and Power-House Structures," A. Major; ENGRS DIGEST, v 18, n 11, November, 1957, pp 507-508.

81. "Metallurgy Makes Difference," F. G. Sefing; DIESEL POWER, v 35, n 11, November, 1957, pp 35-39.

82. "Control of Steam-Jet Vacuum Pumps," C. G. Blatchley; ASME, paper n 57-F-15, September 23-25, 1957, 7 pp.

83. "Some Operational Problems of Nuclear Power Plant," A. R. Jones and R. L. Witzke; AIEE TRANS, v 76, Pt I (Communication and Electronics), n 32, September, 1957, pp 373-377.

84. "Screw-Displacement Pump," THE SHIPPING WORLD, v 137, August 7, 1957, p 119.

85. "Aluminum Bronzes for Marine Application," W. L. Williams; ASNE J, v 69, n 3, August, 1957, pp 453-461.

86. "Centrifugal Pumps---Correct Installation and Starting Give Them Good Lease on Life," E. Schwandt; PLANT ENGRN, v 11, n 8, August, 1957, p 114.

87. "Heavy Fabrication at Wishaw," WELDING AND METAL FABRICATION, v 25, n 8, August, 1957, pp 290-296.

88. "Design and Application of Marine Free-Piston Gas Generators," M. A. Augustin-Normand and M. E. Barthalon; ASNE J, v 69, n 3, August, 1957, pp 570-576.

89. "Composite Maintenance Plan Effective," H. K. Tatum; ELECTRIC LIGHT AND POWER, v 35, n 13, June 15, 1957, pp 162-163.

90. "Preliminary Operation---Shippingport Atomic Power Station," E. M. Parrish; ASME, paper n 57-SA-55, June 9-13, 1957, 6 pp.

91. "Aluminum Heating Coils," THE SHIPPING WORLD, v 136, June 5, 1957, pp 546-547.

92. "Fifty Years of Sulzer Diesels," DIESEL PROGRESS, v 23, n 6, June, 1957, pp 42-43.

93. "Simplified Controller for Oil-Fired Boilers," ENGINEERING, v 183,

n 4759, May 24, 1957, p 656.

94. "Gas and Steam Turbine Combined," H. J. Blaskowski and J. G. Singer; COMBUSTION, v 28, n 11, May, 1957, pp 38-44.

95. "Marine Engineering Notes from the Soviet Press," B. M. Kassell; ASNE J, v 69, n 2, May, 1957, pp 309-318.

96. "Brown Boveri Gas Turbines," H. Pfenninger; BROWN BOVERI REVUE, v 44, n 4, April, 1957, p 200; v 44, n 5, May, 1957, p 190.

97. "Dynamic Field Tests of Steam Turbine," P. R. Hoyt, B. D. Stanton, D. C. Unim; ASME, paper n 57-IRD-15, April 8-10, 1957, 5 pp.

98. "Diphenyl as a Thermocynamic Fluid," D. C. Purdy; NUCLEONICS, v 15, April, 1957, pp 109-112.

99. "Are Conventional Components Delaying Nuclear Progress?," NUCLEONICS, v 15, n 4, April, 1957, pp 78-79.

100. "Application of Diesel Engines to Marine Industry," F. S. Driscoll; SAE, paper for a meeting of the New England Section, March 5, 1957.

101. "Great Nuernberg Oil Engine," MAR ENGR AND NAV ARCH, v 80, n 966, March, 1957, pp 84, 101.

102. "Automatic Controls Protect Your Investment," D. Martin and J. G. Allen; DIESEL POWER, v 35, n 3, March, 1957, pp 32-33.

103. "Modern Steam Turbine Feed Systems," A. D. Bonny; read at a meeting of NECIES, v 73, February 22, 1957, p 253.

104. "The Development of Refractory Nozzle Blades for High Temperature Gas Turbines," T. H. Blakeley and R. F. Darling; read at a meeting of NECIES, v 73, February 8, 1957, p 231.

105. "Highly Pressure Charged German Diesel Engine," MAR ENGR AND NAV ARCH, February, 1957, pp 45-49.

106. "First Commercial Supercritical-Pressure Steam Turbine---Built for Philo Plant," C. W. Elston and R. Sheppard; ASME TRANS, v 79, n 2, February, 1957, pp 417-426.

107. "Some Fuel Characteristics Which Affect Diesel Engine Economy," J. M. Sills and W. A. Howe; SAE, paper n 8, January 14-18, 1957, 43 pp.

108. "Experience with Highly Pressure-Charged Engines," K. Zinner; BRIT MOTORSHIP, v 37, n 440, January, 1957, p 420.

109. "New Method for Shaft Aligning," BUREAU OF SHIPS J, v 5, January, 1957, p 40.

110. "Hydraulically Operated Reverse-Reduction Gear," MAR ENGRN/LOG, v 62, January, 1957, pp 94, 96.

111. "Marine Diesel Engineering in 1956," BRIT MOTORSHIP, v 37, n 440, January, 1957, pp 414-419.

112. "Engine Damaged by High Temperature Steam," MAR ENGR AND NAV ARCH, Annual Steam Number, 1957, pp 481-482.

113. "Some Operational Problems of the Nuclear Power Plant," A. R. Jones and R. L. Witzke; SECOND NESC, paper n 57-NESC-24, 8 pp.

1956

114. "Maintenance Is Business---Make It Produce!," C. T. Maxwell, Jr.; POWER ENGRN, v 60, n 11, November, 1956, pp 70-72, 131, 133; v 60, n 12, December, 1956, pp 106-109.

115. "Progress in Application of Automatic Controls to Naval Boilers," C. H. Barnard and H. D. Vollmer, Jr.; SNAME, paper n 4, November 15-16, 1956, 9 pp.

116. "Maintenance Control in Steam Power Plants," G. V. Williamson; ELECTRIC LIGHT AND POWER, v 34, n 24, November 15, 1956, pp 102-105.

117. "Factors Influencing Shaft Alignment," R. E. Kosiba, J. J. Francis, R. A. Woollacott; MAR ENGRN/LOG, v 61, October, 1956, pp 83-84, 117.

118. "Prevent Pump Headaches," C. R. McFarland; POWER, v 100, n 10, October, 1956, p 122.

119. "Hydrogen Peroxide as Propulsive Agent," P. G. Morgan; MAR ENGR AND NAV ARCH, v 79, n 959, September, 1956, pp 310-312.

120. "Enterprise Builds Powerful Vee Diesel Power," DIESEL POWER, v 34, n 9, September, 1956, pp 30-33.

121. "Maintaining Nuclear Reactor Plants," R. E. Crews and J. M. Yadon; POWER, v 100, n 8, August, 1956, pp 104-106, 188, 193; v 100, n 9, September, 1956, pp 87-89; v 100, n 11, November, 1956, pp 90-91.

122. "Tanker with Turbines of Novel Design," THE SHIPPING WORLD, v 135, August 8, 1956, pp 117-123.

123. "Fireman Aboard Modern Combatant Ships," G. J. Rascher; ASNE J, v 68, n 3, August, 1956, pp 547-553.

124. "Preventive Maintenance for Boiler Instruments," L. Walter; STEAM ENGRN, v 25, n 297, July, 1956, pp 303-305; v 25, n 298, August, 1956, pp 350-352, 358; v 25, n 299, September, 1956, pp 392-394.

125. "Conditions of Failure in Some Turbine Diaphragm Blades," K. H. Khalil; ENGINEER, v 202, n 5243, July 20, 1956, pp 78-80.

126. "Widdop Engine with Independent Blowers," BRIT MOTORSHIP, v 37, n 433, June, 1956, p 64.

127. "Some Problems in Maintenance of Nuclear Reactors," H. G. Davey; ENGINEER, v 201, n 5233, May 11, 1956, pp 481-483.

128. "Doxford Engine; Progress and Development," A. Storey; INTERNATL SHIPBLDG PROGRESS, v 3, n 21, May, 1956, pp 265-284.

129. "Automatic Control Equipment for Application to Marine Boilers," K. R. Longes; I MAR E TRANS, v 68, n 5, May, 1956, pp i-viii (supplementary section).

130. "Weakest Link, Ship Auxiliary Propulsion," R. T. Sutherland, Jr.; ASNE J, v 68, n 2, May, 1956, pp 225-230.

131. "German High-Speed Diesel," GAS AND OIL POWER, v 51, May, 1956, pp 116-119.

132. "Electromagnetically Operated Pilot-Injection System," ENGRS DIGEST, v 17, April, 1956, p 128.

133. "High Temperature Fatigue in Presence of Thermal Stresses," L. F. Coffin; ASME TRANS, v 78, April, 1956, pp 527-532.

134. "An Introduction to Nuclear Energy," J. M. Kay; NUCLEAR ENGRN, v 1, n 1, April, 1956, pp 36-38.

135. "Steam Cycles and Nuclear Power Plant," R. E. Zoller; I MECH E SYMPOSIUM ON NUCLEAR ENERGY PROC, March 28, 1956, pp 29-39.

136. "New Marine Gas Turbine," THE SHIPPING WORLD, v 134, March 28, 1956, pp 301-302.

137. "Advantages of Gas Turbine Plant," MAR ENGR, v 61, February, 1956, p 83.

138. "Welding Grey and Nodular Cast Iron," W. A. Schumbacker and A. L. Schaeffler; BRIT WELDING J, v 35, February, 1956, pp 91S-99S.

139. "Marine Reduction Gearing," A. W. Davis; given before I MECH E, January 20, 1956, p 477.

140. "Service Performance of Free-Piston Generator Plants," SHIPBLDG AND SHIPG REC, v 87, January 19, 1956, pp 79-80.

141. "Technical Progress in Marine Engineering during 1955," SHIPBLDR AND MAR ENG BLDR, v 63, n 572, January, 1956, pp 25-34.

142. "Metallizing Saves Stainless Steel Shaft," INDUSTRY AND WELDING,

v 29, n 1, January, 1956, pp 74-76.

143. "Defects of the Modern Marine Diesel Engine," A. F. Evans; GAS AND OIL POWER, v 51, January, 1956, pp 23-25.

1955

144. "Protection of Condensers for Ship's Refrigeration Plants," CORROSION TECHNOLOGY, v 2, December, 1955, p 374.

145. "Maintenance Control in Steam Power Plants," G. W. Williamson; ASME, paper n 55-A-174, November 13-18, 1955, 8 pp.

146. "Maintenance Factors Affecting Production Costs," W. F. Oberhuber and C. W. Watson; presented before ASME Diamond Jubilee Annual Meeting (Chicago, Ill.), paper n 55-A-128, November 13-18, 1955.

147. "Choosing Rings for Top Performance," D. D. Cook; BRIT MOTORSHIP, v 40, n 11, November, 1955, pp 26-28.

148. "Turbocharged Nohab-Polar MN-Series Engines," MAR ENGR AND NAV ARCH, v 78, n 948, November, 1955, pp 419-421.

149. "Research on High Speed Journal Lubrication," MAR ENGR AND NAV ARCH, v 78, October, 1955, pp 393-394.

150. "Plastic Ductwork," H. J. Stark and A. E. DeSomma; BUREAU OF SHIPS J, v 4, August, 1955, pp 20-22.

151. "American Gas Turbine Developments," BUREAU OF SHIPS J, v 4, August, 1955, pp 26-27.

152. "Preparation of Residual Fuel for Motive Power," F. H. Smith and F. P. Downing; ASME, paper n 55-OGP-1.

153. "Free-Piston Propulsion Plant for Liberty Ship," J. J. McMullen; ASME, paper n 55-OGP-14.

1946

154. "Combustion Studies of the Diesel Engine," E. W. Landon; SAE J, v 54, June, 1946, pp 270-288.

1945

155. "Lubrication Characteristics of Involute Spur Gears," E. K. Gatcombe; ASME TRANS, v 67, April, 1945, pp 177-188.

DATES UNAVAILABLE

156. "Fundamental Concepts of Incremental Maintenance Costs as Used by Ohio Edison Company," D. B. Zelenka and R. H. Travers; AIEE TRANS, v 78, Pt IIIA, pp 163-165.

157. "Laboratory and Field Evaluation of Connectors and Other Accessories for Aluminum Conductors in Severe Marine Environments," W. J. Sanders; AIEE TRANS, v 78, Pt IIIB, pp 1342-1353.

158. "Present-Day Large Steam-Turbine Generator Design Practice," J. J. Fleischmann and G. W. Staats; AIEE TRANS, v 77, Pt III, pp 1348-1353.

UNREAD ARTICLES

1961

1. "Design of Modern Boiler Feed Pumps," H. H. Anderson; presented at a meeting of I MECH E, March 16, 1961.

2. "Fatigue Strength of Marine Shafting," G. P. Smedley and B. K. Batten; read at a meeting of NECIES, February 24, 1961.

3. "Factors Influencing the Fatigue Resistance of Connecting-Rod Big-End Bearings," E. A. Blount; read at a meeting of I MECH E, February 16, 1961.

4. "Modern Steam Turbine Design and Operation," A. F. Veitch; read at a meeting of NECIES, January 27, 1961.

5. "Device for Lessening Corrosion and Formation of Scale in Steam Boilers," T. Creed; CERTIFICATED ENGINEER, v 34, n 1, January, 1961, pp 11-13.

1960

6. "Developments in Marine Steam Turbine Design," T. W. F. Brown; read at a meeting of IESS, December 20, 1960.

7. "The Oxidation of Reactor Steels in Carbon Dioxide," C. Moore and T. Raine; IRON AND STEEL INSTITUTE, from a symposium on steels for reactor pressure circuits held at The British Nuclear Energy Conference, November 30-December 2, 1960.

8. "Improvements in or Relating to Rotary Shaft Seals and Pumps Provided with Such Seals," H. E. LaBour; British Patent 854,526, November 23, 1960.

9. "Dynamic Testing Machine for Large Diesel Engine Bearings," O. Holfelder; LIGHT METALS BULLETIN, v 23, n 21, October 12, 1960, p 971.

10. "Corrosion Wear of Cylinder Liners of Diesel Engines Using Residual Oil," G. Simonetti; CORROSION TECHNOLOGY, v 7, n 10, October, 1960, pp 315-319, 334.

11. "Non-Destructive Techniques in Power Plant Inspection," P. W. Sherwood; COMBUSTION, v 32, n 4, October, 1960, pp 44-48.

12. "Protection of Steam-Turbine Blades Against Water-Drop Erosion by Spark-Hardening," Y. F. Kosyak and P. U. Savukov; ENGRS DIGEST, v 21, n 9, September, 1960, pp 123-124.

13. "Corrosion-Resisting Valves," H. E. Threlfall; NUCLEAR POWER, v 5, n 53, September, 1960, pp 100-102.

14. "Gas Valves for Nuclear Power Stations," C. D. Blakeborough; NUCLEAR POWER, v 5, n 53, September, 1960, pp 96-99.

15. "Vane Type Pump with Kingsbury Slippers," J. M. Roth and D. L. Roth; ENGRS DIGEST, v 21, n 76, August, 1960, p 82.

16. "Repair of Failed Nuclear Thermal-Hydraulic Experimental Loop Vessel," E. B. LaVelle; BRIT WELDING J, v 39, n 8, August, 1960, pp 802-807.

17. "Manufacture and Maintenance of Marine Diesel Parts," F. Danis; IRON AND STEEL INSTITUTE J, v 159, July, 1960, p 363 (abstract).

18. "Reliability Study: Equipment and Components in Nuclear Power Plants (A Final Engineering Report)," Gilbert Associates (Reading, Pennsylvania); GAI-1512, July, 1960.

19. "Continuous-Cast Bronze Bushings," SCIENTIFIC LUBRICATION, v 12, June, 1960, pp 20-21.

20. A list of bibliographies on nuclear energy, INTERNATIONAL ATOMIC ENERGY AGENCY (Vienna), June, 1960.

21. "Economics of Engine Power Development of Alco 251 Engine," P. S. Vaughan; ASME, paper n 60-OGP-11, May 22-26, 1960, 12 pp.

22. "ERDL-NPFO Quarterly Progress Report No. 11," C. Eicheldinger; MND-E-2009 (Martin Co. Progress Report), April, 1960.

23. "Liquid Cooled Gas Turbine for 1750° F," S. Alpert, R. E. Grey, W. O. Flaschat; GAS AND OIL POWER, v 55, May, 1960, pp 124-129.

24. "Marine Machinery Failures," H. N. Pemberton; MACHINERY MARKET, n 3098, March 31, 1960, pp 21-24; n 3099, April 7, 1960, pp 25-28; n 3100, April 14, 1960, pp 21-22.

25. "Synthetic Rubber-Faced Stern Tube and Strut Bearings," L. S. Thompson; BUREAU OF SHIPS J, v 9, March, 1960, pp 42-43.

26. "Detergent Oils for Diesel Engines," H. Halliwell; BUREAU OF SHIPS J, v 9, March, 1960, pp 27-28.

27. "Planned Maintenance of Large Direct Drive Diesel Installations," BRIT MOTORSHIP, v 40, March, 1960, pp 455-456.

28. "Unconventional Centrifugal Pumps," U. M. Barske; read at a meeting of I MECH E, February 3, 1960.

29. "Anti-Whirl Turbine Bearing," SCIENTIFIC LUBRICATION, v 12, February, 1960, pp 17-18.

30. "Corrosion Pitting of Iron in Distilled Water," CORROSION TECHNOLOGY, v 7, February, 1960, p 40.

31. "Starting Fluids for Diesel Engines," J. F. Blose and W. Anderson; BUREAU OF SHIPS J, v 9, February, 1960, pp 24-25.

32. "Twelve Cylinder 18,240 bhp Japanese-Built Sulzer Engine," BRIT MOTORSHIP, v 40, February, 1960, pp 430-431.

33. "NSU-Wankel Rotary Engine," SHIPBUILDING EQUIPMENT, v 2, February, 1960, pp 14-15.

34. "Gas Turbines Experience-Record," J. W. Sawyer; GAS TURBINE, v 1, n 1, January-February, 1960, pp 22-25.

35. "Influence of Silicon in Cast Iron on Corrosive Wear," R. Graham, O. S. Prado, M. H. Collins, E. A. Brandes, H. K. Farmery; paper submitted to I MECH E, 1960.

1959

36. "Design and Construction of Feedwater Heaters," J. V. Bigg; read at a meeting of I MECH E, December 9, 1959.

37. "Problems Associated with the Use of Bunker 'C' Fuel," J. J. McMullen; presented at a meeting of the New York Metropolitan Section of SNAME (New York), December 8, 1959.

38. "Effect of Nuclear Radiation on Engineering Materials," A. H. Cottrell; presented at a meeting of I MECH E, November 25, 1959.

39. "Extreme Pressure Lubricants for Marine Gears," A. D. Newman; paper read at a meeting of I MECH E, November 11, 1959.

40. "High Alloys of Chromium, Cobalt, Columbium, Molybdenum, and Vanadium," H. R. Ogden; ENGINEERING MATERIALS AND DESIGN, v 2, n 10, October, 1959, pp 490-493.

41. "Main Boiler Operation and Maintenance," J. A. Stevens and J. Honey; TANKER TIMES, v 6, October, 1959, pp 136-139.

42. "Open Submersible Motors," J. W. Bouvy; BUREAU OF SHIPS J, v 8, October, 1959, p 22.

43. "Flame Ceramic Coatings for Pistons, Valves, Heads," DIESEL PROGRESS, v 25, n 10, October, 1959, pp 32-33.

44. "High Temperature Alloy Considerations in Steam Turbine Designs," N. L. Mochel; ASME, paper n 59-PWR-12, September 27-30, 1959, 31 pp.

45. "Ponca City Has Largest Dual Fuel," DIESEL PROGRESS, v 25, n 9, September, 1959, pp 24-26.

46. "An Investigation of Diesel Engine Oil Filtration and Abrasive Wear with High Detergency Lubricants by Means of Radioactive Tracer Techniques," H. Halliwell; NP-8426, August 20, 1959, 32 pp.

47. "Plate Heat Exchanger," BRIT MOTORSHIP, v 40, July-August-September, 1959, p 155.

48. "Trials of Gas Turbine Ship AURIS," BRIT MOTORSHIP, v 40, July-August-September, 1959, p 151.

49. "Application of Diesel Engines to Automatically Controlled Power Plants," K. L. Ives; DEUA, paper n S265, June, 1959, pp 1-15, 16-25 (discussion).

50. "Longer Life for Centrifugal Pumps---Cause and Cure of Cavitation and Corrosion," N. B. Heops; CHEM ENGR, v 66, n 9, May 4, 1959, pp 156, 158, 160.

51. "Service Experience of Liberty Ship Conversions Involving Four Different Propulsion Systems," R. Y. Newell, Jr. and T. J. Chwirut; paper presented at a meeting of the Chesapeake Section of SNAME (Washington, D. C.), April 2, 1959.

52. "Gas Turbine Progress Meeting," GAS TURBINE PROGRESS MEETING (Pentagon, Washington, D. C.), April, 1959. This is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D. C. ($1.25).

53. "Modern Trends in High Speed Diesel Engines," L. D. E. Brodie; DEUA, report n S263, April, 1959, pp 36-43.

54. "Economic-Type Boiler Defects and Repairs," S. D. Scorer; STEAM ENGRN, v 28, n 330, April, 1959, pp 224-228; v 28, n 331, May, 1959, pp 276-282; v 28, n 332, June, 1959, pp 293-295; v 28, n 333, August, 1959, pp 342-345; v 28, n 334, September, 1959, pp 375-377.

55. "Light-Weight 8000 HP Gas Turbine for Marine Propulsion," V. Proscino; ASME, paper n 59-GTP-18, March 8-11, 1959, 10 pp.

56. "Operating Experience with Gas Turbine Ships of Maritime Administration," C. C. Tangerini and D. H. Specht; ASME, paper n 59-GTP-16, March 8-11, 1959, 20 pp.

57. "Some Corrosion Problems in Gas-Cooled Reactors," M. W. Davies; GENERAL ELECTRIC COMPANY ATOMIC ENERGY REVIEW, v 2, n 1, March, 1959, pp 11-17.

58. "Mechanical Impedence Methods for Mechanical Vibrations," R. Plunkett; NOISE CONTROL, v 5, March, 1959, p 35.

59. "Corrosion in Boilers," W. Gumz; BSRA J, v 14, abstract n 15051, February, 1959.

60. "Right Materials Ease Maintenance of Nuclear Power Plants," W. L. Fleischmann and S. L. Williams; MATERIALS IN DESIGN ENGINEERING, v 49, n 1, January, 1959, pp 73-75.

61. "Mechanism of Gear Lubrication," V. N. Borsoff; ASME TRANS, SERIES C, J OF BASIC ENGINEERING, v 81, 1959, pp 79-88.

62. "Stress Corrosion of Stainless Steel and Boiler Water Treatment at Shippingport Atomic Power Station," W. J. Singley, I. H. Welinsky, S. F. Whirl, H. A. Klein; AM POWER CONFERENCE PROC, 1959, pp 748-766.

63. "Automatic Boiler Control," E. Samal; AEG PROGRESS, n 3, 1959, pp 241-253.

64. "Marine and Mobile Applications of Industrial Gas Turbines," E. O. Kohn; ASME, paper n 59-A-295.

65. "Oil Ash Corrosion of Superheater Alloys," N. O. Philips and C. L. Wagoner; ASME, paper n 59-A-281.

66. "Development of 3500 HP Marine Gas Turbine," D. W. Knowles; ASME, paper n 59-A-199.

67. "Description and Service Experience of Various Boeing Gas-Turbine Marine Applications," V. A. Yeager; ASME, paper n 59-GTP-8.

1958

68. "Gas Turbine Auxiliaries," SHIPBUILDING EQUIPMENT, v 1, November, 1958, pp 10-11.

69. "Electric Ship Propulsion," E. L. N. Towle; METROPOLITAN-VICKERS GAZETTE, v 29, n 470, September, 1958, pp 232-247.

70. "Sprayed Tungsten Carbide," SHIPBUILDING EQUIPMENT, v 1, September, 1958, p 12.

71. "Nuclear Reactors for Ships," W. Junkermann; BSRA J, v 13, abstract n 14,540, September, 1958.

72. "Large Diesel Engines for Ship Propulsion," F. Schmidt; BSRA J, v 13, abstract n 14,183, June, 1958.

73. "Maintenance Routines," DEUA, paper n S258, May, 1958, pp 1-17, 18-28 (discussion).

74. "Bearing Metal," J. J. Coppen; DEUA, publication S258, May, 1958, pp 7-8.

75. "The Bunker C Fuel Oil System of the Gas Turbine Ship JOHN SERGEANT,"

C. C. Tangerini and A. D. Foster; presented before the Chesapeake Section of SNAME (Washington, D. C.), April 3, 1958.

76. "Oil Hydraulic Drives," H. Rauchberg; BSRA J, v 13, abstract n 13,903, March, 1958.

77. "Review and Evaluation of Maintenance Concepts for Liquid Metal Fuel Reactors," J. J. Happell; BABCOCK AND WILCOX COMPANY, BAW-1047, March, 1958, 115 pp. Available from OTS, Washington, D. C. ($3.00).

78. "Marine Applications of Gas Turbines and Free Piston-Gas Turbines," J. W. Sawyer and G. L. Graves, Jr.; DIESEL AND GAS TURBINE PROGRESS, Pt I, February, 1958; Pt II, March, 1958.

79. "Turbomachines for Nuclear Power Plants," R. A. Strub; SULZER TECHNICAL REVIEW, v 40, n 3, 1958, pp 59-70.

1957

80. "Study of Bearings under Failure Conditions," T. W. F. Brown; SCIENTIFIC LUBRICATION, Special Conference Issue (read at the Conference on Lubrication and Wear, 1957), December, 1957, p 65.

81. "Fatigue Strength of Crankshafts," A. T. Wuppermann, Stahl, Eisen; BSRA J, v 12, abstract n 13,457, November, 1957.

82. "Liquid Metal Seal for Sodium Pump Shafts," S. C. Carniglia; NAA-SR-Memo-2184 (Atomics International), October 4, 1957.

83. "Cavitation Erosion---A Review of Present Knowledge," D. J. Godfrey; GREAT BRITAIN S AND T MEMO, n 17/57, September, 1957, 16 pp.

84. "Design Features of a Gas Turbine for Supercharged Boiler," J. M. Baker, J. B. Gilbert, W. B. Moyer; presented at the Autumn Meeting of ASME, paper n 57-F-31, 1957.

85. "Operational Experience with Four Types of High Pressure Boilers," J. P. Ricard; BSRA J, v 12, abstract n 13,167, August, 1957.

86. "Proposed Guide for Operation and Maintenance of Turbine Generators," AIEE, n 67, July, 1957, 26 pp.

87. "Preventive Maintenance for Boiler Instruments," L. Walter; COAL UTILIZATION, v 11, n 7, July, 1957, p 19.

88. "Operation, Maintenance and Control of Boiler Plant," A. N. Sen Gupta; INSTITUTION OF ENGINEERS J (India), v 37, n 10, Pt 2, June, 1957, pp 957-968.

89. "Maintenance of Shell Boilers," J. N. Williams; STEAM ENGRN, v 26, n 305, March, 1957, pp 190-191; v 26, n 306, April, 1957, pp 240-241, 243; v 26, n 307, May, 1957, pp 274-275; v 26, n 308, June, 1957, pp 309-310; v 26, n 309, July, 1957, pp 346-347; v 26, n 310, August, 1957, pp 374-376; v 26, n 311, September, 1957, pp 418-420; v 26, n 312, October, 1957, pp 22-23; v 26, n 313, November, 1957, pp 42-44.

90. "Cause and Cure of Trap Troubles," NATIONAL ENGINEER, v 61, n 3, March 4, 1957, pp 26-29.

91. "Control of Low Temperature Flue Gas Corrosion; Causes, Effects, and Methods of Prevention," STEAM ENGRN, v 26, n 303, January, 1957, pp 111-115.

92. "Gas Turbine Power for Merchant Ships," WIGGIN NICKEL ALLOYS, n 43, 1957, pp 5-8.

1956

93. "Devices for Damping Mechanical Vibration," M. Benton; NP-6257, December, 1956, 101 pp.

94. "Research in High Temperature Bearing Lubrication in the Absence of Liquid Lubricants," R. A. Coit, S. S. Soren, R. L. Armstrong, C. A. Converse; WADC-TR-56-370 (Pt III), November 1, 1956, 44 pp.

95. "Hydrodynamic-Type Gas Bearings," G. W. K. Ford, D. M. Harris, D. Pantall; presented at a General Meeting of I MECH E, October 26, 1956.

96. "Supercharging Large Two-Stroke Engines with Transverse Scavenging," BSRA J, v 11, abstract n 12,127, October, 1956.

97. "Flow Induced Vibrations in Heat Exchangers," B. J. Grotz and F. R. Arnold; STANFORD UNIVERSITY (Department of Mechanical Engineering), contract n 25 (23), technical report n 31, August, 1956, 49 pp.

98. "Preventive Maintenance for Boiler Instruments," L. Walter; STEAM ENGRN, v 25, n 297, July, 1956, pp 303-305; v 25, n 298, August, 1956, pp 350-352, 358; v 25, n 299, September, 1956, pp 392-394.

99. "Diesel Engines or Steam Turbines for High Speed Merchant Vessels?," J. deTellaeche; BSRA J, v 11, abstract n 11,816, July, 1956.

100. "Mineral Oils as High Temperature Fluids and Lubricants," E. E. Klaus and M. R. Fenske; WADC-TR-56-254, June, 1956, 38 pp.

101. "Diesel Engine Manufacture---Cast Iron Failures," DEUA, paper n S247, June, 1956, pp 1-20, 21-30 (discussion).

102. "Reheat Applied to Turbines of High Output," B. Lendorff, G. Burkhard, K. Wirz; ESCHER WYSS NEWS, v 29, n 2, May-August, 1956, pp 28-38.

103. "Corrosion Resistance of Aluminum Alloys," BSRA J, v 11, abstract n 11,659, May, 1956.

104. "Problems in Steam Machinery," BSRA J, v 11, abstract n 11,633, May, 1956.

105. "Cylinder Wear in Marine Diesel Engines," BSRA J, v 11, abstract n 11,608, May, 1956.

106. "Protect Your Feed Pump Against Reverse Rotation," T. W. Edwards and I. J. Karassik; INDUSTRY AND POWER, v 70, n 5, May, 1956, pp 52-54.

107. "Industry Learns from Turbine Spindle Failure," R. G. Matters, R. E. Lochen, P. A. Dedinas, H. K. Ihrig; J OF METALS, v 8, n 3, March, 1956, pp 317-324.

108. "Combating Cylinder Wear and Fouling in Large Low Speed Diesel Engines," M. J. VanDerZijden; read at a meeting of I MECH E, February 28, 1956.

109. "Fretting and Fretting Corrosion," LUBRICATION, v 11, February, 1956, pp 13-23.

110. "Structural Materials for High-Temperature and High-Pressure Steam," BSRA J, v 11, abstract n 11,279, February, 1956.

111. "High Pressure Steam Piping for Marine Turbines," J. R. Olie; HOLLAND SHIPBUILDING, v 4, February, 1956, pp 24-25.

112. "Sodium and Sodium-Potassium Alloy as Heat Transfer Medium," W. B. Hall and T. I. M. Crofts; read at a meeting of THE BRITISH NUCLEAR ENERGY CONFERENCE, January 18, 1956.

113. "Bearings for Marine Geared Turbines," INTERNATL SHIPBLDG PROGRESS, v 3, n 26, 1956, pp 528-539.

114. "Some Factors Governing Welfare of Steam Boilers and Other Pressure Vessels," F. Shapley; LIVERPOOL ENGINEERING SOCIETY TRANS, v 77, 1956, pp 26-37, 38-45 (discussion).

115. "Corrosion Fatigue," I. Cornet; NACE, paper n 20, 1956.

116. "Full-Scale Tests and Operational Performance of Steam Washers," L. G. Friedle (Dow Chemical Co.); AM POWER CONFERENCE, paper, 1956.

117. "Design and Testing Considerations of Lubricants for Gear Applications," E. E. Shipley (General Electric Co.); ASLE, paper, 1956.

118. "Lubrication in the Presence of Nuclear Radiation," R. O. Bolt and J. G. Carroll (California Research Corp.); ASLE, paper, 1956.

119. "Spray Application of Lubricants to Plain Roll Neck Bearings," C. M. Winn and J. S. Aarons (U.S. Steel Corp.); ASLE, paper, 1956.

1955

120. "Aqueous Homogeneous Power Reactors," R. B. Briggs and J. A. Swartout; BSRA J, v 10, abstract n 11,038, December, 1955.

121. "Some Design Aspects of Free-Piston Gas Generator-Turbine Plant," W. A. Morain and S. L. Soo; ASME, paper n 55-A-146 and 55-A-155, November 13-18, 1955, 45 pp and 23 pp.

122. "What Nuclear Power Will Mean to Power Plant Auxiliaries," I. J. Karassik and T. W. Edwards; INDUSTRY AND POWER, v 69, n 5, November, 1955, pp 54-57.

123. "Hard Anodizing of Aluminum," ALUMINUM NEWS (Montreal), October, 1955, p 7.

124. "Dynamic Loading of Gear Teeth," ENGRS DIGEST, v 16, September, 1955, p 403.

125. "Combustion in Large Diesel Engines," P. Jackson; paper read at a Joint Conference on Combustion held by ASME and I MECH E, 1955.

126. "Combustion Products and Wear in High-Speed Compression-Ignition Engines," W. T. Lyn; paper read at a Joint Conference on Combustion held by ASME and I MECH E, 1955.

127. "Pumping of Sodium Hydroxides in Nuclear Reactors," N. E. Miller and M. Simons; NUCLEAR ENGINEERING AND SCIENCE CONGRESS 1, 1955.

128. "Water for Primary Systems in Water-Cooled Power Reactors," D. M. Wroughton, J. M. Seamon, H. F. Beeghly; NUCLEAR ENGINEERING AND SCIENCE CONGRESS 1, 1955.

DATES UNAVAILABLE

129. "Electro-Magnetic Coupling Alternators," BRITISH THOMSON-HOUSTON ACTIVITIES, v 26, n 3, pp 70-74.

130. "Cr-Mo-V Low-Alloy Steels for Service at Elevated Temperatures," ALLOY METALS REVIEW, v 8, n 94.

131. "Design and Evaluation of HAPO Canned Motor Pump," AT(45-1)-1350 (General Electric Hanford Atomic Products Operation).